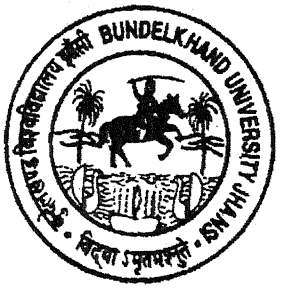
PRETREATMENTS TO BREAK THE DORMANCY OF SOME FOREST TREE SEEDS



THESIS

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TO
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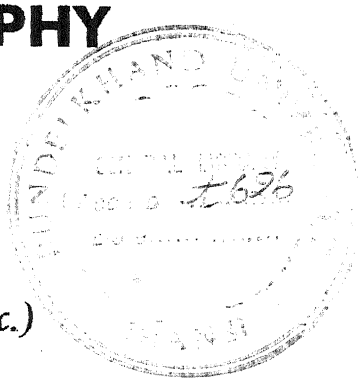

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2003

DEDICATED

TO

PRIYAM-RAMESHWARAM

MY

GRAND MOTHER AND GRAND FATHER

DECLARATION

I hereby declare that the thesis entitled "**Pre Treatment to Break The Dormancy of Some Forest Tree Seeds**" being submitted to Bundelkhand University, Jhansi for the Degree of Doctor of Philosphy in Botany is an original piece of research work done by me and to the best of my knowledge and belief the thesis or any part of the thesis has not been published in any other University or Examining Body in India or abroad earlier.

(Rajeev Baweley)

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CERTIFICATE

It is to certify that the thesis entitled "Pre-treatments to break the dormancy of some forest tree seeds" is an original piece of research work done by Rajeev Baweley, M.Sc. (Botany) under my guidance and supervision for the degree of DOCTOR OF PHILOSOPHY in Botany of Bundelkhand University, Jhansi (U.P.) India.

I further certify that :

(I) the thesis has been duly completed

(II) it embodies the work of the candidate himself

(III) the candidate has worked under me for more than 24 months at the Institute from the date of registration

(IV) the thesis fulfils the requirements of the ordinance relating to the Ph.D. degree of the University, and

(V) it is up to the standard both in respect of the contents and literary presentation for being referred to examiners.

(U.N. Singh)

Guide/Supervisor

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Date : 5-12-2003

(Rajeev Baweley)

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INTRODUCTION

INTRODUCTION

All the living beings are depend upon plants. Plants are the producers in the ecosystem on which all the trophic levels or consumers depend. They are essential for all living being on this globe. They are the only natural machinery converting the radiation energy of sun in to chemicals or food stuffs. They can fix the carbon -di-oxide of air into food materials.The plants are the main factors of environment, without them there would be an imbalance of environment, resulting the damaging or poisoning the atmosphere.

Protection of environment mostly depends upon vegetational cover of soil or land. A clear understanding of quality and germination of seeds is necessary for establishing such a cover in any area. The major part of vegetation is forest.

"A forest is a peculiar organization of unlimited kindness and benevolence that makes no demand for its sustenance and extends generously the products of its life activities" written by Lord Buddha in his preachings. "It affords protection to all beings, offering shade even to the axe-man who destroy it". This indicates that the significance and usefulness of forest was realised by man even in the very old days.

Living resources (Food & Forests) essential for human survival and sustainable development are being destroyed increasingly. At the same time, human demand of these resources is growing very fast. If the current rate of land and forest degradation continues, about one-third of the world's forest

land will be destroyed in the next 20 years. By the end of this centuary, the remaining area of unlogged productive tropical forests will be halved and during this period the world population is expected to increase by almost half (Gadgil,1991).

It is an established fact that trees are useful to men in two distinct ways, (1) as the producer of a wide variety of goods commonly called"Forest produce" and (2) as custodians of favourable environmental conditions. It would not make sense to try to qualify one of these functions as more important than the other. Both are indispectably essential to the well being, indeed to the survival of man. The increasing populations of human beings as well as animals are facing an acute problem of wood and fodder, etc. as the forest-cover from the earth's surface is shrinking regularly and with a fast speed. It has been assessed that after a few decades, we may have sufficient food grains because of our devoted scientific efforts in agriculture, but we may not have enough fuel to cook our food. The forest cover is reducing due to several development activities like urban settlements, roads and industries etc. It is also reducing because of open-cast mining operations in large areas as well as its diversion to agricultural purposes and excessive biotic interference.

Accelerated degradation of woodlands is a major ecological challange of the late twentieth century. In many countries of the world, the number of trees planted increases each year. In addition to new planting, replanting of harvested plantations of non-coppicing species must be carried out on a considerable scale each year. Forest plantations are a powerful tool in continuing

efforts of foresters to increase productivity per unit area. It is the only means of reconciling the increasing demands for forest products. Plantations also offer the means by using a large scale of genetically improved material which is developed by tree breeders (Willan.1985).

Forests play a vital role in maintaining natural water flows and water quality. Forests are also critical in regulating hillslope stability and ensuring stream channel integrity. Trees intercept precipitation, which alters both the amount of water that reaches the soil and the rates at which snow accumulates and melts, so removing trees may alter the magnitude and timing of peak flows in stream channels. Forests play a significant role in maintaining the slope stability of wet, mountainous soil. In the past, when the roads and harvesting were placed in inappropriate locations, there were order-of- magnitude increases in landslide rates and sediment delivery to streams. As consequence, there were changes to flow and sediment-loading in stream channels, which adversely affected their stability. By removing trees and large woody debris, past forest harvesting of streamside areas jeoparadized stream bank integrity and channel roughness, and contributed to widened and unstable rivers (Anon,1998).

Water becomes part of the terrestrial hydrologic cycle when it falls as rain or snow. Weather precipitation falls as one or the other depends on the location, elevation, climate and time of year. Not all of the precipitation falling on a watershed reaches the ground. In mature forests, between 20% and 30% of the precipitation does not make it to the forest floor ; it remains on leaves and branches or is absorbed by material in the canopy. From there, it evaporates

directly back to the atmosphere. When trees are harvested or defoliated by fire, insects or disease, more total precipitation reaches the ground . Rain that reaches the ground either infiltrates the soil, where it is stored or drains to streams, or moves on the surface as overland flow to streams (Anon, 1998).

Deforestation influences countries and their people in many ways. Shortage of wood products influences the daily life of millions of people in rural and urban communities; shortage of construction timber influences house building; shortage of fuelwood influences cooking habits, the time women (mainly) spend with their children or in agriculture production etc. Environmental degradation is often closely linked to deforestation. Soil degradation, siltation of waterways, occasional floodings etc. are all immediate of long-term effects of deforestation that affect millions of people in tropics today (Schmidt, 2000).

Forest plantations covered 187 million hectares in year 2000, of which Asia accounted for 62%. In the top ten countries according to total area, India was placed second having 17% forest cover (Anon, 2001).

Among all kinds of plants, spermatophytes or seed plants are most important to man. They are best adapted to cultivation and furnish directly or indirectly, most of the food and clothing for the entire world.

The natural forests in tropical countries are a mixture of various speices with lesser number of desired trees. Consequently, large scale afforestation and reforestation programmes of single useful species were undertaken to grow monocultures. However, natural selection of species could

not be easily changed in such trials.

Forestry in several developing countries is undergoing a rapid transformation from natural to man-made forest. Natural forests, often consisting of hundreds of indigenous species, are being replaced more and more by a few selective native or exotic species of economic values. The natural forests are being considered unsuitable for fulfilling the increasing demands of industrial wood in many developing countries. This is due to their mixed nature, slow growth rate, less desired timber properties etc. Wood utilising industries usually need an uniform raw material, preferably of a single or a few species, so that the processing can be made as effective and economical as possible. All these factors have contributed in shifting from natural to man made forests (Kamra, 1975).

Since seeds are usually the basic material for plantation, their demand for the desired species is continuously rising. In order to obtain healthy, better yielding and more plants from the available seeds, the study about their structure, germination and physiology is essential. Unfortunately, not much is known about these aspects of seeds of many tropical forest tree species. This gap of knowledge is one of the important hinders to meet the plantation requirements in several countries (Schmidt, 2000).

The chief problem regarding the seeds in our country is their need in large quantities which makes it necessary to collect all the available seeds both of good and poor quality (genetical as well as technical). Since seed setting is not regular in most of the species, usually there is a shortage of seeds. Rising

demand of seeds and increasing cost of labour and other things, force us to have one plant from each and every seed even in wide range of environmental conditions.

Most of the forestry programme starts with seeds, therefore, an adequate supply of good quality seeds is of fundamental importance in such programmes. Understanding of seeds that can be used in various climatic, geographic and soil conditions is of prime importance. Seeds are affected by the methods of collection, processing and storage. Insects, fungi, bacteria etc.often attack fruits and seeds during development and storage and reduce their quality and quantity.

Another reason for getting low quality seeds is that, in view of providing year round wages and incident income to the very poor tribals and villagers, the forest department gives the work of collection of forest tree seeds to them who have no scientific understanding of good and bad seeds. They are also not guided properly and are normally illiterate thus, can not keep the record of collection data. Lack of such information does not permit the researches to correlate the performance of seeds with any of the factors related to their origin.

The problem relating to germination of seeds, their viability and dormancy constitute an important aspect of forest species. In Bundelkhand area, most of the abandoned area remain barren for a long period of the year. The seed plants well adjusted to this region may provide good vegetation cover of the soil. Moreover, the indigenous and well adaptive tree species can give promising results to cover the barren area. Many such trees produce hard seeds

which do not germinate easily in normal conditions. Plantations of such trees have been taken by forest department by growing the seeds in the nurseries. To facilitate easy germination of seeds, present work has been taken.

CHAPTER - II

STUDY AREA
DESCRIPTION OF TREES
SEED AND SEED DORMANCY

STUDY AREA

LOCATION AND TOPOGRAPHY :

Bundelkhand region of Uttar Pradesh, comprising of six districts namely Banda, Hamirpur, Jalaun, Jhansi, Lalitpur & Mahoba, is located in 24°11' - 26°27' N. latitude and 78°17' - 80°34' E longitude. It is bounded by the Yamuna river in the North escarped ranges of the Vindhyan plateau in the south, the Chambal river in the North-West and Panna-Ajaigarh ranges in South - East .

Topography of region is characterised by its smooth flat lands and intermixed undulating topography of varied slope, with the exception of the Southern marginal areas which still retain the features of dissected plateau, the entire region is marked by subduded topography that tends to grade a level plain towards the north.

GEOLOGY AND SOIL :

This region is covered by four geological systems viz. Archean, Vindhyan, Transitional and Recent deposites. These are represented by common rocks as crystalline, igneous, metamorphic, sand stones, lime stones, granites and gnreisses. The peculiar features of immense geographic interest in the area are long narrow serrated ridges termed as quartz, reefs and dolarites.

In the region there are two major soil groups viz., 1. Red soils and 2. Black soils. Red soils are coarse grained ,upland soils and are found primarily in Jhansi and Lalitpur districts. Black soils are heavy soils and are distributed

in low lying areas of Jalaun, Hamirpur, Mahoba and Banda districts. These major soils are further classified according to their texture and colour into four distnict series namely Rakar and Parwa in Red soil group and Kabar and Mar in blace soil group.

CLIMATE AND VEGETATION :

The climate of the region is characterised by a transitional climate between the maritime climate of the east coast (Bay of Bengal) and the tropical continental dry type climate of the west (Rajasthan). The rainfall varies between 750 mm in the North - West to about 1200 mm in South - East. About 90% of the total precipitation is recieved between July to the end of September with occasional showers during winter months. The distribution of rainfall is often erratic and even wet months i.e. July and August which recieve about 70% of annual total, many times experience long dry spells. May and June are the hottest months and record maximum temperature of 43°C to 46°C, and the minimum temperature reaches to 4° - 5°C during January with reports of occasional freezing temperature. The area is termed as semi - arid with moisture index from 40 to 60.

The region is ecologically degraded and the original vegetation has almost been removed for inhabitation and cultivation. Shrubs and grasses represent the secondary growth throughout the region. Babool is the principal type of ***Acacia.*** Khair is the common tree but not much utilized. Hingota, Karnodha and Kareel are mostly utilized for grazing.

Albizia procera (Siris), *Anogeissus pendula* (Dhawana), *Tectona grandis* (Teak), *Butea monosperma* (Dhak), *Salmalia malabarica* (Semal), *Boswellia serrata* (Salai), *Dalbergia sissoo* (shisham), *Acacia catechu* (Khair), *A. nilotica* (Babool), *Zizyphus mausitian* (Bair), *Carissa carandus* (Karondha), *Capparis aphylla* (Kareel), *Balanites aegyptica* (Hingota), *Albizia lebbeck* (Kala siris) are the main contributors in the natural vegetation of this region. Experiments were carried out in the Department of Botany, D.V. (P.G.) College, Orai (Jalaun).

DESCRIPTION OF TREES

Following trees producing hard seeds were selected for present study.

Acacia auriculiformis (Benth) A. Cunn.

Family - Mimoseae (Fabaceae)

A. auriculiformis was first introduced to India in West Bengal in 1946 to raise in laterite areas. It is now one of the main species in reforestation of degraded forests, grass - lands and even roadsides, not only as a cover crop and to meet the ever increasing fuelwood demands of the country but also as a nurse crop with an ultimate aim of introducing shade loving and more valuable evergreen species under it. The strong objection of environmentalists against raising *Eucalyptus* has given further impetus to this species, in India's plantation programmes. Being an evergreen species, it keeps the barren hill slopes characteristically green all through the year and improves the soil through its nitrogen fixing roots and litter. It has now been widely accepted as an indispensable species for various locations. It has also been mixed in plantations

with ***Eucalyptus hybrid*** , ***Cassia siamea, Casuarina equisetifolia, Dalbergia sissoo*** and ***Acacia nilotica*** (Kaushalapa, 1991).

It is a useful sand binder. Bark contains tannin with high tan/nontan ratio. Seeds contains a fatty oil (Anon, 1986).

Acacia catechu willd. 'KHAIR'

Family - Mimoseae (Fabaceae)

A. catechu is a small or medium sized deciduous tree, occurring on a variety of geological formations and soils. It is essentially a tree of comparatively dry regions, though, it extends into regions of heavy rainfall (Troup, 1921 a). It is a valuable tree producing Kattha, cutch, timber and bark which are of great economic use. Kattha is widely used as an indispensable ingredient in the preparation of chewing pan (Piper beetle leaf). Kattha is cooling, digestive and very valuable astringent specially in chronic diarrhoea and dysentry, bleeding piles, uterine haemorrhages, leucorrhoea, chronic bronchitis etc. (Anon, 1973). Cutch is used in dyeing cotton and silk and in calico - printing. The timber is used in house construction and also for making rice pestles, oil and sugarcane crushers. This species has been classified as 'super group' timber suitable for large spans more than 12 m. and is placed as the first choice of selection for permanent structures. The wood is also used as fuel and furnishes charcoal of good quality. The gum from this species also belongs to a good cadre. The juice of fresh bark of this species has medicinal properties and is given with asafoetida in spitting of blood. A paste of bark is useful in conjunctivitis (Anon, 1973).

'Khaersal' a natural product, collected from the cavities of old trees, much used as a remedy in relaxed throat. It is sweetish and astringent in taste (Dey, 1988).

Acacia nilotica (Benth.) Brenan 'Babool'

Family - Mimoseae (Fabaceae)

Acacia nilotica is probably indigenous to North Deccan including Andhra Pradesh, Maharashtra, Rajasthan and Gujrat (Troup, 1983). The species has played an important role in afforestation schemes of the dry zone, fuel and fodder reserves, strip plantations on road sides, canal sides and along railway lines. It has been recognised as one of the most important species for social forestry schemes also. The species has also been widely planted and distributed in semi arid regions of Pakistan, Sudan and other African countries. It is essentially a tree of the plains, occurring on flat or gently undulating and ravine country but seldom extending into hilly regions above 450 m. in elevation. It grows on a variety of soils.

Preparations are babul - arista and lavangadivati ; gum which is a good substitute for improted gum arabic, is useful in making pills, lozenges and tablets.

In action it is anthelmintic, antidote to poisoning , aphrodisiac, astringent, demulcent, diuretic, emollient, expectorant, nutritive, soothing and styptic. Useful in chronic dysentry and diarrhoea, cough, gastro - intestinal catarrh, haemorrhagic ulcers, leucorrhoea, leprosy, piles, prolapsus - ani, vaginal affections, seminal weakness, skin deiseases, sore - throat and congestion of

throat, sores and ulcers and genito - urinary catarrh (Dey, 1988).

Albizia lebbek (Benth.) 'Siris'

Family - Mimoseae (Fabaceae)

It is a moderate sized or large deciduous tree extensively planted in gardens, along road sides and in other places. In nature, it is found wild in sub Himalayan tract, Bengal, Andaman etc. It is a tree of the mixed deciduous forests, both in dry and moist types, usually occurring scattered and not gregariously.

'Siris' is extensively planted as an avenue tree, and in tea and coffee plantations as a cover crop. The shed leaves make good manure. The bark is used for the same purpose as the gum arabic is used.

The heartwood is used for high class furniture, cabinet work, interior decoration and panelling. It is suitable for building purposes, oil pressures, agricultural implements, cartwheels and bodies, railway sleepers, house posts, carving and trunery articles, picture frames etc. It is fairly suitable for tennis racquets and opium chests (Anon, 1948).

In action siris is considered as alterative, aphrodisiac, astringent, collyrium, dentifrice, expectorant, restorative and tonic. Effective in asthma, cervical gland enlargement reduced, cough and cold, diarrhoea, gums - strengthened, marks and blemishes, night blindness, piles, seminal fluid thicker and retainer, scrofulos and skin erruptions (Dey, 1988).

Albizia lebbek can withstand extremes of climate - long hot, dry summers and cold winters and is a very promising species for fuel forest (high

calorific value, 5200 Kcal/kg), foliage for feed, and furniture timber yield to the tune of $5m^3$/ha. The tree also has the additional advantage of fixing atmospheric nitrogen in the soil (Vir - Satya ***et.al***, 1994).

Cassia fistula Linn. 'Amaltash'

Family - Caesalpiniaceae (Fabaceae)

A modrate sized tree scattered in deciduous forests with a rather open crown ; leaves peripinnate with 4-8 leaflets 2-6 inches long. It is one of the most beautiful of Indian flowering trees. Wood hard and durable, in demand for house - posts, carts and agricultural implements, pulp of the pods is a strong purgative (the Cassia Pulpa of the British Pharmacopoeia), while bark is used for tanning.

Common in deciduous forests throughout the greater part of India occurring to 400 ft. in the Himalayas, occurs fairly frequently in Sal forests, sometimes approaches gregariousness in locality frequented by monkeys. It is found on a variety of geological formation and grow on poor shallow soil.

The long pendulous racemes of large bright yellow flowers appear chiefly with the new leaves, seeds are embaded in a dark brown sweetish pulp which is a strong purgative. They are 0.3 - 0.4 inches by 0.2 - 0.3 inches, ovate compressed, light brown, hard, smooth, shing, with a moderately hard testa and a horny albumem. Like many other hard leguminous species, seeds of this species also take some time to germinate, sometimes a whole year, even it regularly watered (Troup, 1921 a).

Cassia siamea Lam.

Family - Caesalpiniaceae (Fabaceae)

Cassia siamea is a tree of tropical climate where frost is unknown. It is probably indigenous to Burma but planted throughout India as roadside avenue, as an ornamental tree and is also cultivated for firewood (Singh, 1982). Its dark colour wood makes excellent fuel (Anon, 1930). The species is thus ideally suited for energy plantation.

This species cheifly recommended for wind breaks, irrigated and canal plantations in dry and semi - dry tropical countries. It is also cultivated for ornamental purposes and to some extent in plantations throughout the greater parts of India (Date, 1987).

Leaves of this species are eaten by cattle, sheep and goats, but an alkaloid present in the leaves has been found to be fatal for the pigs. (Prasad, 1944).

Old wood of this species is almost black, very strong, hard and heavy. It deserves to be used for furniture. Flowers are used as a vegetable and leaves as manure (Ambasta, 1986).

Other reported uses of this species are nitrogen fixation. Soil conservation stabilization, beeforage, live fencing and hedgerows (Kandya, 1990).

Delonix regia (Boj) Rafin. 'Gulmohar'

Fam - Caesalpiniaceae (Fabaceae)

D. regia is a fairly large deciduous ornamental tree with broad

spreading umbrella shaped crown and light, feathery foliage reaching a height of about 18 m. under favourable conditions. The tree is often planted as an ornamental tree in garden and as an avenue tree along highways. The leaves are much valued as manure for paddy cultivation as they rot quickly. Its wood is also used for furniture making. The root is used to remove the pain of scorpion bite and the leaves and flowers are used as medicine (Troup, 1975). Seeds contain gum and are used in textile and food industries (Anon, 1986).

Leucaena leucocephala (Lam.) de Wit. 'Su - Babool'

Family - Mimoseae (Fabaceae)

This species has attracted global attention during last few years owing to its multidimensional use in the rural set up. It is already being tried as one of the major species in social forestry in various parts of our country (Gujrat, Maharashtra, Karnataka, Rajasthan, to a limited extent in Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, Bihar and Orissa ; Lohani, 1979).

Leucaena being a multipurpose tree type (MPT) is being exploited in tropics and sub - tropics for various important uses especially for fuel, fodder, small timber, afforestation and for improvement of soil health.

Besides its uses as forage, paper pulp, fuel and timber, it also contributes greatly to the fertility status of the soil by adding 500 kg of nitrogen per hectare per year by fixing nitrogen from the air by its nodular roots (Vietmayer, 1979 ; Relwanii, 1980).

Cattle feeding on ***Leucaena*** foliage recorded weight gains comparable to those cattle feeding on the best pasture anywhere. Also the nitrogen rich

foliage placed around crops have resulted in crop yield increase comparable to those achieved by use of commercial fertilizers. ***Leucaena leucocephala*** is used as livestock feed during the most critical periods (dry season) of the year (Amodu ***et al.***, 2000).

Parkinsonia aculeata Linn ' Vilayati Kikar'

Family - Caesalpiniaceae (Fabaceae)

Tree loped for fodder. Seeds edible, contain glutelin and albumin as principal proteins. Bark yields a fibre suitable for mixing with paper - pulps. Wood yields good charcoal, also used as fuel (Anon, 1986).

Pithecellobium dulce Benth. 'Jangal Jalebi'

Family- Mimoseae (Fabaceae)

Very suitable for hedges and as fuel as it has fast rate of growth, coppices vigorously and can stand any amount of pruning, lopping and browsing. Pods used as fodder and seeds eaten raw, or in curries. Saline extract of seeds shows a hemolytic agglutinating reaction with human blood. Yield a fatty oil used for edible purposes and for soap manufacture , may also be used as a substitute for kapok seed and groundnut oils. Meal has a high protein content (29.7%) and may be used as an animal feed. Bark contains tannin. Leaves serves as fodder. Wood used for general construction (Anon, 1986).

Prosopis juliflora (SW) DC. 'Vilayati babool'

Family- Mimoseae (Fabaceae)

Prosopis juliflora (SW) DC, commonly known as Vilayati babool, was first introduced in India in 1877 around some areas in Sindh, then a part of

undivided India. Later, the species was introduced in many parts of the country and today, this species has spread over larger parts of tropical arid and semi - arid tract of the country. This species has proved to be the most versatile for afforestation on shifting sand dunes, coastal sands, eroded hills and riverbeds , saline terrains, dry degraded grasslands and waste lands with scanty and erratic rainfall (Muthana, 1988; Bohra *et al.*,1994).

Spongy walls of ripe pods are highly nutritive ; a fair source of digestible protein and of importance as a stock feed. Pods also used as staple food often removal of the seeds and coarser parts. They are ground into a meal and made into cakes, or used in the preparation of an alcoholic beverage ; seeds ground into powder for preparing bread, foliage can also be fed to livestock both in fresh condition and as hay. Gum used as an emulsifying agent ; it also finds use in confectionary and in preparations used for mending pottery. Wood used for house building, railway cross ties, furniture and turnery also used for fence posts. A process of manufacturing hardboard sheets without use of binder has been invented. Wood, roots and bark contain tannin (Anon, 1986).

SEED

A seed, which is very little in size and weight, posses an admirable programme for creation of a huge tree weighing several tonnes. This programme , controlled by the chromosomes of the seed's embryo, starts its precision work in cooperation with the environment when suitable conditions for seed

germination are provided. Consequently, the future properties of a tree depend upon the interaction between the internal consititution of seed and its environment.

Seeds represent the means for survival and spread of most species of higher plants. Directly or indirectly, they are the only source of life sustaining nutrients for all consumers. Symbiotically, they represent removal and illustrate the tenacity of life in the face of a hostile world. After dispersal throughout myriad, terrestrial and aquatic environments, the dormant seed remains poised to sprout or to germinate at the first signal from the environment of better times for the perpetuation of life.

True seeds and dry, one seeded fruits (functionally seeds) are derived normally from fertilized matured ovules. They contain an embryonic plant (embryo), food storage tissue and an enveloping coat consisting of integuments, testa, pericarp and accessory floral parts of bracts (Kozlowski and Gunn, 1972). The seed is highly organised packet of energy which is provided for the complete development of the primary plant body of the emergent seedling.

With the seed, the independence of the next generation of plant begins. The seed, containing the new plant in minature, is equipped with structural and physiological devices to fit it for its role as a dispersal unit. It is well provided with food reserves which sustain the young plant until a self sufficient, autotrophic organism is established.The embryonic plant is protected within its coverings. Its metabolic activities, at an extremely low ebb, are often not to be re-awakened until some considerable time is passed or a particular

environmental stimulus is experienced (Bewley and Black, 1978).

Seed is of fundamental importance in forestry practice. It is usually with seeds that most of the afforestation and reforestation programmes start. It was only during the last centuary when the foresters realized that, for a successful reforestation, seeds of high physiological and genetical quality must be used. In the modern silvicultural practice, often the seeds are sown in the nursery and the seedlings obtained from them at a certain age, are transplanted in the field. Thus to produce high number of seedlings in the nursery, good quality seeds must be sown .

As man is striving ceaselessly to improve the chain of forest generations, it is necessary that the seed workers have to devote a great interest both to the origin of a seed as well as to its behaviour when it starts a new generation.

The modern technique for production of plants in plastic green houses, nurseries and field puts more emphasis on the genetic and physiological seed quality than the earlier conventional methods did. For instance, in the single seed - container method, each ungerminated seed results in an empty container. Such blind containers are indicative of the economical loss. By improving the seed germinability, this loss can be reduced to a minimum.

Essentially, a seed consists of an embryo supplied with food reserves which may be present as fats or oils, or more commonly as starch or proteins in the cotyledons or in the endosperms. Basically, an embryo consists of a plumule and a radicle, which give rise to the shoot and root respectively.

During germination, the food reserves are transformed by enzymes into soluble substances which are transported to the plumule and the radicle to enable them to grow. The radicle grows rapidly and forms the root system which establishes the seedling in the soil and absorbs water and nutrients. The plumule produces the shoot to bear green leaves which can photosynthesize. Thus, a young plant aims to becoming self supporting as rapidly as possible, virtually, before the food reserves in the seed are exhausted.

From this description, it appears that the production of a seedling from a seed is a simple and systematic procedure. But, in fact, there are many problems involved in this process. From the collection to the sowing, the seed passes through several stages and an unfavourable treatment at any stage can lead to the reduction of its vitality or even to its death. Thus, from the time of collection of fruits, cones or seeds, to processing and storage, the seed has to be handled carefully. Seeds of different species have their own requirements and must be treated accordingly. The production, handling and testing of seed form a science by itself which needs a constant and continuous research to understand and solve the various problems involved (Kamra, 1973).

Certainly, a seed is a very minute organ in comparison to the huge tree on which it is created. However, the seed is the important link between two generations of a plant. It transmits the characteristics of that generation which has produced it, to the generation which will arise from it.

SEED DORMANCY

WHAT IS DORMANCY :

Many seeds do not germinate if placed under conditions, normally regarded as favourable for germination, i.e. adequate water supply, suitable temperature and normal composition of the atmosphere. Such seeds, if germinate through any means are said to be dormant or to be in a state of dormancy (Mayer and Poljakoff - Mayber, 1963).

According to Evenary (1956), dormancy in seeds can be defined as a condition of perfect and viable seeds which makes them resistant for germination under those environmental conditions that are ordinarily favourable for quick germination.

It has been suggested by Toole (1958) that any seed which requires for the onset of germination certain conditions which are different from those required for continued development of the seedling, is in the broadest sense, dormant.

UTILITY OF DORMANCY :

For the continuance of any plant species, seed dormancy is a very desirable trait. Such seeds not only remain viable for long time, but, under natural conditions, individual seed becomes permeable at different periods. Thus most of the seed lots are capable of producing some seedlings over a period of several years. In this way life span of several seeds is extended (Crocker and Barton, 1953).

Mall and Manilal (1962) emphasized that seed dormancy is an

adaptive property and is correlated with the distribution of plants in nature.

Ability of seeds to retain viability for prolonged periods without germinating is one of the most important adaptive properties of plants. This allows them to survive during adverse seasonal conditions in the soil (Nikolaeva, 1977).

Thus , delayed germination is often of value to man as well as to the plants. It is essential that seeds have at least a short dormant period after harvest, so that they do not sprout and ruin. There are numerous examples of seeds remaining viable but dormant from a few days to thousands of years (Crocker and Barton, 1953).

Types of Dormancy :

According to Asakawa (1963), seed dormancy is divided into two types - (1) Physiological which can be overcome only through the mediation of certain physiological processess ; and (2) Physical - which can be overcome only by some kind of physical treatment.

Basically seed dormancy indicates the unability of seeds to germinate under favourable conditions which may be due to any one or more of the following causes (Maguire, 1975) :

(1) immature embryos,

(ii) seed coats impermeable to water and/ or gases,

(iii) inhibitors, (iv) physiological maturity,

(v) light sensitivity , (vi) mechanical restriction by seed coats.

Dormancy may also be secondarily imposed by adverse environmental conditions. For the plants, seed dormancy is a means of survival. To the

grower, it may be a problem that affects systemic crop establishment, growth, harvest and uniformity of seed development (Maguire, 1975).

Effect of seed coat :

Mechanism by which the seed coat imposes dormancy is poorly understood. But the evidence points to a number of possibilities. The covering structures may prevent embryo germination because they :

(a) interfere with water uptake,

(b) interfere with gaseous exchange,

(c) contain chemical inhibitors,

(d) act as a barrier against the escape of inhibitors from the embryo,

(e) modify the light reaching the embryo,

(f) exert a mechanical restraint

(Bewley and Black, 1978).

Hard seed coats :

The term 'hard' has been quite generally applied to seed coats which do not absorb water necessary for germination of seeds. A very wide-spread cause of seed dormancy is the presence of a hard seed coat.

In the present study, all the selected trees produce hard seeds. Normally these seeds do not germinate when sown in the nurseries for raising the plants. Certain pretreatments are necessary for such seeds to facilitate germination. Which pretreatments are most suitable for a particular seed lot is to be worked out. Screening of various methods have been done in detail to get the most suitable seed pretreatments for all the species taken for study.

CHAPTER - III

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Seed coat is impermeable to water which mainly affect germination. Mechanical or chemical scarification or manual removal of seed covering almost always improved germination (Crocker and Barton, 1953).

Improvement in germination percentage of ***Delonix regia*** seeds was obtained by treating them with boiling water or H_2SO_4 (Duarte, 1974).

In ***Cardiospermum helicacobum*** hard - seedness persisted up to two years and acid treatment (scarification) was required to obtain germination (Heit, 1974).

Kemp (1975) enumerates seed scarification, soaking in water, chemical treatment, stratification and radioactive and sound treatments for various seeds to overcome dormancy. Turnbull (1975) also suggested certain prosowing treatments to break seedcoat dormancy in forest tree seeds.

Brolmann (1975) used heat treatment to obtain germination of the hard seeds of ***Stylosanthes guyanensis.***

Stratification, soaking of seeds in cold and hot water or in chemicals (H_2SO_4, GA_3, Uric acid, H_2O_2, Thiourea etc.), scarification and infra-red irradiation might be useful methods for breaking seed dormancy in various economic tree species (Carnerio, 1975).

Seed germination of ***Centrosoma pubescens*** was increased from 30% to more than 80% by 20 minute treatment with sulphuric acid or by mechanical scarification (Pe ***et al.***, 1975).

In Japan, Hyakawa and Maki (1976) used heat to eliminate the hard seeds in various ecotypes of ***Medicago sativa.*** They also found that the hard seeds could be eliminated by storage at low temperature (- 5 to - 25°C). Chemical scarification with H_2SO_4 has been proposed to overcome hard seed dormancy in many species. ***Acacia cyanophylla*** seeds treated with conc. H_2SO_4 had 98.5% germination as compared to the 4% of untreated seeds (Shaybany and Rouhani, 1976).

In Philippines, hot water (80°C) treatment for 1 minute gave the best (90%) germination in seeds of ***Leucaena leucocephala*** (Alvarez-Racelis and Bagaloyos, 1977).

Heit (1977) described that removal of seed coat mechanically or by acid treatment was useful in enhancing the germination of seeds. Effect of H_2O_2 and chilling on seed germination of ***Tilia*** spp. was also observed by him.

Treatment of seeds of ***Elettaria cardamomum*** with 25% HNO_3 for 10 min. increased their germination percentage form 19 to 66 (Sulikeri and Kololgi, 1977).

Treatments involving acid or mechanical scarification were found to be the only methods that significantly increased germination of ***Sophora chrysophylla*** seeds in U.S.A. (Scowcroft, 1978). Hot water (90°C) treatment and stratification at 4°C for 4 weeks gave about 100% germination in ***Acacia melanoxylon*** seeds. (Zwaan-1978).

In ***Glycine wightii, Macroptilium atropurpurium, Pueraria phaseoloides*** and ***Centrosoma pubescens*** seeds, scarification, especially by

H_2SO_4, increased germination, and mechanical scarification by sand paper was found to have a moderate effect. ***P. phaseoloides*** exhibited induced germination after heat treatment, and hot water treatment was found effective in ***M. atropurpureum*** and ***C. mucunoides*** seeds. (Almeida ***et al.*** , 1979).

In Australia, Gilbert and shaw (1979) found that hot water (65°C to 95°C) treatment significantly increased germination of ***Stylosanthes hamata*** and ***S. viscosa*** seeds.

Hsu and Chung (1979) in Taiwan, recommanded that hot water (80°C) allowed to cool upto room termperature was the simplest treatment for ***Leucaena leucocephala*** seeds for large scale use.

In Brazil, Oliveira ***et al.*** (1979) found that 60°C temperature for a longer duration was the best for germination of ***Leucaena leucocephala.*** He scarified the seed by 13 hot water treatments (2 to 90 minutes exposures at 60,70 and 80°C temperature).

Sheikh, (1979) found that treatment of seeds of ***Ceratonia siliqua*** for 30 minutes ; ***Sapindus mukorossi*** for 20 minutes, and ***Pistacia khinjuk*** for 15 minutes with concertrated H_2SO_4 significantly increased their germination percentage.

In ***Leucaena leucocephala*** hot water (80°C) treatment for 3 min was found suitable by Pound (1980).

Everitt (1983) found that soaking of seeds of ***Parkinsonia aculeata*** and ***Acacia schaffner*** in conc. H_2SO_4 for 45 min. increased germination over 50% form 1% and 5% respectively.

In Brazil, Bakke and Goncalvis (1984) reported that concentrated H_2SO_4, hot water treatment and mechanical scarification were found to be useful in breaking the dormancy and enhancing germination percentage (97, 92 and 91) of seeds of ***Prosopis juliflora.***

In the seeds of ***Parkia pendula,*** concentrated H_2SO_4 for 20 and 30 minutes and cutting of seeds opposite to the point of radicle showed a wide range of enhancement in the germination betwen 53% to 70% (Barbosa ***et al.***, 1984).

Willan (1985) additionally mentions dry heat and fire as appropriate methods to break the seed coat domancy in many forest tree species.

Kariuki (1987) found that nicking gave significantly better enchancement of germination than the other pretreatment tested in ***Acacia xanthophloea.*** Sulphuric acid and boiled water gave reasonable enhancement of germination of the hard coated ***Cassia siamea*** seeds.

A marked improvement in germination following treatment with conc. H_2SO_4 has been found by Halepyati ***et al.*** (1987) in ***Sesbania rostrata*** seeds.

The best response was found to be conc. sulphuric acid for 24 minutes and soaking for 24 hrs. in boiling water in ***Prosopis*** spp. (Lopez and Aviles, 1988).

Kariuki and Powell (1988) found that sulphuric acid and hot water treatments enhanced germination but appearently, these pretreatments also harmed some seeds of ***Acacia xanthophloea*** and ***Trachylobium verrucosum.***

Aswathaiah (1988) found that piercing of seed coat was fruitful to elimi-

iate the hardseedness in *Vicia* spp.

In some selected *Acacia* species from the Pilbara region of Western Australia, Gunn (1989)experienced nicking to improve the percentage germination of seeds.

Seeds of ***Acacia macracantha*** and ***Cyathostegia mathewsii*** showed improvement in germination rates when soaked in cold water for 48 hours while ***Capparis angulate*** did not respond to treatment (Zevallos & Silva, 1991).

Varela ***et al.*** (1991) found that the germination was best for seeds which was manually scarified and immersed in water for 6 hours in ***Stryphnodendron pulcherrimum*** while hot water (90°C) and sulphuric acid (96%) treatments inhibited germination.

Soaking in water and application of IAA, GA_3 and thiourea before or after scarification promoted seed germination to over 90% within 6 days of incubation at 20 - 30°C as against 18 - 30% in the seeds of ***Prosopis glandulosa*** (Farrukh and Ilahi, 1991).

The seed of ***Robinia pseudoacacia,*** pretreated for 24 hrs in hot water at 70°C and sulphuric acid for 1 hr. increased the germination rate (Oaris & Cannata, 1992). Acid scarification gave a greater percentage of normally and physiologically germinated seeds.

Nasroun and Al-Mana (1992) used mechanical scarification of the seed coat and soaking seeds in conc. sulphuric acid to improve germination in the seeds of some arid zone tree species such as ***Acacia nilotica***, ***A. tortilis, Prosopis glandulosa, Delonix regia, Albizia lebbek***, etc.

Ferreira ***et al.*** (1992) found improvement in germination percentage of seeds by scarification mechanically by a lateral, small cut on the integument in ***Acacia bonariensis*** and ***Mimosa bimucronata.***

Danthu ***et al.*** (1992) reported better germination of ***Acacia senegal*** seeds due to water soaking for 12 to 24 h. with respect to vigour index, continuous hot water soaking was found to be superior over wet treatments.

Working with the multipurpose west African forest species, ***Dialium guineense,*** Todd and Duryea (1993) used conc. sulphuric acid, various heat treatments-in cold, warm, hot or boiling water and dry heat or fire, mechanical treatment nicking, milling or grinding for pretreatments of seeds. Nicking and conc. sulphuric acid treatment effectively improved the germination. Sulphuric acid pretreatment recommended for well - equipped centralized nurseries, whereas nicking is more appropriate for small village nurseries.

Demel (1993) pretreated the seeds by soaking in H_2SO_4 for 1, 3 or 5 min. & 3 or 5 min. in boiling water. He found that scarification with H_2SO_4 increased germination (84%) and removal of seed coat and pericarp resulted in 100% germination in the light and 99% in the dark in the seeds of ***Vernonia galamensis.***

Seeds of ***Enterolobium contortisiliquum*** pretreated with water at 100°C for 2 min, 3 min or until water fell to room temp or in 75% H_2SO_4 for 15, 30, 60 or 90 min. Generally sulphuric acid was most effective in breaking dormancy and increasing germination percentage (Eira ***et al.***, 1993).

In the seeds of ***Terminalia ivorensis,*** pre - treatment by conc. H_2SO_4

for 3 hrs gave the best germination (Corbineau and Come, 1993).

Conc. sulphuric acid pretreatment was found to be most effective for ***Cassia siberiana*** for large scale community. Mechanical scarification, nicking and sand paper lining found to be the most effective for rural community level (Todd ***et al.***, 1993).

Masano & Mawazin (1994) found that slicing of the end of the seeds gave best germination (92%) compared with control (86.7%) in the seeds of ***Tamarindus indica*** while the hot water treatment reduced it to 22.7%.

In some ***Acacia*** species the following pre - treatments were tried to remove the hard seededness ; 100°C dry heat or boiling water for 1,2,4,8 or 16 min. Heat treatment and boiling water was the most effective in reducing hard - seededness and promotes germination (Magnani ***et al.***, 1994).

Idu (1994) found that scarification with concentrated sulphuric acid for 15 min. resulted in 93% germination in the seeds of ***Bixa orellana*** while untreated seeds of this species showed poor germination as being hard coated, seeds could not be imbibe readily when placed in water.

Nearly 100% germination was obtained within one week after seeds were placed in sulphuric acid (concentrated) for 120 min. Nicking the seed coat with a razer blade also resulted in near 100% germination in the seeds of ***Lupinus havardii*** (Mackay ***et al.*** , 1995).

In Baobab (***Adansonia digitata***) seeds, treatment with conc. sulphuric acid for six to twelve hours led to seed germination more than 90% (Danthu ***et al.*** ,1995).

Cavalcante ***et al.*** (1995) used conc. sulphuric acid for 40 min for scarification of ***Leucaena leucocephala*** seeds. Similarly, in ***Lupinus havardii*** seeds, 100% germination was obtained after seeds were placed in sulphuric acid (Mackay ***et al.*** , 1995).

Demal (1996) used mechanical scarification and conc. sulphuric acid treatment for 15, 30, 45 and 60 sec. on the seeds of five ***Senna*** species. Mechanical scarification gave 100% germination and sulphuric acid scarification for 60 min. gave 95-100% germination in all the species.

In another experiment with some leguminuous species (***Acacia albida, A. seyal, Albizia lebbek, Delonix regia, Prosopis juliflora,*** etc.), same auther in the same year (Demel, 1996 a) reported that concentrated sulphuric acid scarification improved the germination significantly. Mechanical scarification improved germination in 18 out of 20 species while boiling water treatment improved germination in 15 species but proved to be lethal to 5 species. Germination was significantly improved in 11 out of 16 species treated with dry heat.

In the seeds of ***Faidherbia albida***, pretreatments with sulphuric acid, manual scarification and hot wire burning gave over 90% germination (Diallo ***et al.*** , 1996).

Laroppe ***et al.*** (1996) reported that treatment of seeds with sulphuric acid for 80 min. and storage for at least 8 months improved germination rates in ***Robinia pseudoacacia*** and ***Laburnum anagyroides.***

Piotto and Piccini (1996) found that at all durations of storage,

scarified seeds germinated quicker and to higher percentages than non - scarified seeds for at least 18 months in the carob seeds.

Razz and Clavero (1996) found significant increases in germination occurred with the 5% H_2SO_4 treatment only for ***Humboldtiella ferruginea,*** and for the hot water treatments and the 20% acid treatment for ***Leucaena leucoephala,*** the best treatments were hot water for 30 min (54.48% germination) and 20% acid (61% vs, 16.38% in control).

Demel and Tigabu (1996) performed mechanical scarification, conc. sulphuric acid for 15 to 45 min and 1 to 6 hrs. and boiling water for 1 min to 15 min on the seed of ***Tamarindus indica.*** The best result was obtained (83% vs 72 % germination) when seed treated with sulphuric acid for 15 minutes.

Hermansen ***et al.*** (2000) found that sulphuric acid for 45 min to 90 min and mechanically scarifying the seeds with a file, improved germination (4% to over 90%) in the seeds of ***Dimorphandra mollis.***

In the seeds of ***Pistacia mutica,*** Caloggero and Parera (2000) observed that soaking seeds in sulphuric acid for 5 hours resulted in the highest germination percentage and rate (30% vs from 5% in control).

Mertia and Kunhamu (2000) recorded 100% germination by pre treatments, like soaking in hot water (80°C) for 30 minutes alternate wetting and drying with cold and hot water and mechanical scarification (Partial seed coat removal), with the seeds of ***Salvadora oleoides.***

IN INDIA :

Annual report (1967-68) of Forest Department, Maharashtra,

indicated that pre-sowing treatments stimulated germination in ***Tectona grandis, Albizia lebbeck, Azadirachta indica*** and ***Acacia catechu*** seeds by action of cold, hot and boiling water (Anon, 1970).

Ramakrishnan and Khosla (1971) found that six - minute treatment with concentrated H_2SO_4 was effective for breaking the dormancy of seeds of ***Echinoclora colona.***

Concentrated H_2SO_4 treatment for 3 and 4 minutes gave the highest increase in germination with less mechanical injury and damage in ***Tephrosia perpurea*** seeds (Dharmlingam ***et al.*** , 1973).

Studies conducted in the seed testing laboratory, F. R.I., Dehra Dun have shown that acid treatment was the best for germinating the seeds of ***Acacia catechu*** (Anon, 1974).

Chemical treatment of seeds with concentrated H_2SO_4 for 20 minutes gave 84% germination in ***Cassia fistula*** (Nalwadi ***et al.***, 1975).

Nayak and Mishra (1975) reported that 5 minute treatment of seeds of ***Sida veronicaefolia*** with the concentrated sulphuric acid was good to break their dormancy.

Rai (1976, 78, 79) and Rai & Srinivas (1977) used various methods to overcome the seed dormancy in ***Acrocarpus fraxinifolius, Albizia falcata, A. chinensis, A. richardiana*** and ***Cinnamomum zeylenicum*** etc. They successfully used conc. H_2SO_4 (98%) and dilute H_2SO_4 (10%), Sodium nitrite, Ammonium nitrite, hot water and boiling water treatments for the seeds of these species.

Scarification with conc. H_2SO_4 for 9 minutes in the seeds of ***Robinia pseudoacacia*** gave maximum germination (Pathak ***et al.*** , 1978).

About 90% germination was obtained in ***Jojoba*** seeds by treating them with conc. H_2SO_4 for 2 minutes (Patil and Kaulgud, 1979).

Sharma and Lavania (1979) obtained almost 100% germination in ***Vicia sativa*** and ***V. hirsuta*** after treating the seeds with conc. H_2SO_4 for 1 to 15 min. Rubbing or shaking the seeds for 1 to 20 min. also gave such a high percentage of germination in these species.

Sulphuric acid (10 min), Thiourea (100 ppm), GA3 (100 ppm) and alternating temperature (24 hr. cold/15 min. hot) treatment increased the germination percentage significantly in ***Medicago hispida, M. ciliaris, M. scutellata*** and ***M. murex*** (Yadava ***et al.***, 1979).

Concentrated H_2SO_4 was found to increase the percentage germination (41 to 80) in seeds of ***Santalum album*** (Nagaveni and Srimathi, 1981).

Mechanical scarification and low temperature treatment were found to be effective in enhancing the germination (76% and 68% , respectively) of ***Argemone mexicana*** seeds (Saroha and Bapna, 1981).

Concentrated H_2SO_4 scarification and mechanical scarification at the radicle end failed whereas complete removal of seed coat resulted in 81% germination in ***Podocarpus usambarensis*** seeds (Chamshama and Downs, 1982).

Pandya and Pathak (1980) observed that dormancy can be overcome by acid scarification and thiourea pre treatment on the seeds of ***Achyranthes***

aspera.

Pre-treatments with sulphuric acid were found to be effective to increase the germination percentage and rate of ***Indigofera hirsuta*** seeds (Cantliffe ***et al.***, 1980).

In ***Dichrostachys cinerea,*** sulphuric acid pretreatment for 25 min and hot water pretreatment (85 - 90°C) for 40 min were found to be effective for breaking seed coat impermeability (Roy ***et al.***, 1984).

Kumari and Kohli (1984) found that scarification of seeds of ***Cassia occidentalis*** with sulphuric acid was found to be the best for releasing the seeds off their dormancy.

In the seeds of ***Cenchrus ciliaris,*** Butler (1985) found that predrying (40°C for 10 days) promoted germination.

In the seeds of ***Acacia farnesiana,*** mechanical scarification rendered 98% germination, scarification with concentrated H_2SO_4 and HNO_3 also stimulated germination. Soak and dry and electric shock treatments reduced the time taken for germination while enhancing the germination percentage (Gill ***et al.***, 1986).

Aswathaiah and Delouche (1987) working with 2 hard seeded varieties of vetch seeds (' Nova - II ' and ' Vangard ') observed that a 20-min treatment in conc. H_2SO_4 was most effective in reducing hardseed content without any appreciable loss in total viability.

In the seeds of ***Carica papaya***, Begum ***et al.*** (1987) found that 0.2% thiourea and 50% and 100% cattle urine were highly determined to the seed

germination and seedling growth.

Vidya Chauhan (1988) observed that light mechanical scarification (2 -3 hammer strokes) was most effective method for breaking seed coat/ endocarp seeds dormancy in the seeds of Biul.

Conc. sulphuric acid gave very good result (94% germination) after 60 second - dip in Moong bean seeds (Verma & Singh, 1989) and significant results in Alfalfa (Tomar and Maguire, 1989).

In ***Acacia fernesiana,*** mechanical and chemical scarifications were proved to be most effective pre treatments by Rana & Nautiyal (1989).

In 1990, Sharma and Sood working with the seeds of ***Leucaena leucocephala,*** found conc. H_2SO_4 for 20 min (76.7% germination) followed by hot water dip for 5 min. (75.3%) were useful pretreatments when compared with control values of 19.3% germination. While, Singh ***et al.*** (1990) working with ***Acacia*** species observed boiling water to be the best (90%) followed by sulphuric acid treatment (80% germination).

Vaish ***et al.*** (1992) working with ***Leucaena leucocephala*** seeds found that hot water (95°C) treatment for 80 sec. duration was significantly superior over all other treatments. In the same year, Singh ***et al.*** (1992) reported in ***Lens culineris*** that sand paper abrasion produced 97% normal seedlings followed by hot water treatment (80°C) for 2 min. giving 82% germination.

Sharma ***et al.*** (1992) reported in ***Terminalia belerica*** that seeds soaked in commercial sulphuric acid for 15 minutes gave best results followed by breaking of endocarp with one hammer stroke.

KNO_3 or thiourea was tested for the seed treatment of ***Albizia lebbek*** by Roy (1992). KNO_3 increased germination from 58% to 69%, while thiourea increased to 75%.

Snehlata and Verma (1993) reported in ***Grewia optiva*** that 24 hr. hot water treatment of seeds gave best result (50% vs 28% germination). On the other hand, conc. sulphuric acid for 10 min performed better in ***Albizia lebbek*** seeds (Bimlendra and Toky, 1993). In kasuri methi, sand paper scarification was found to be the most effective method to reduce the hard seededness (Sinha ***et al.***, 1993).

Jarlin and Vadivelu (1994) reported in ***Acacia mellifera*** that acid treatment (conc. sulphuric acid) @ 200 ml/kg seed for 10 min. was the best giving the higher (84.5% compared with 22.6% in the untreated seeds) germination.

Potassium nitrate when used in the scarified seeds of ***Prosopis juliflora*** with sulphuric acid gave higher germination percent (81.5% over 52% in control) as reported by Masilamani ***et al.*** (1994). In the same species Bohra ***et al.*** (1994) reported mechanical scarification to be the best giving more than 90% germination over 5% in control.

Sujit ***et al.***(1994) while working on the seeds of ***Ceiba pentandra*** found that hot water (60°C) soaking of seeds gave best result (63.37% germination over 22.30% in control).

In ***Rubus ellipticus*** fresh seeds treated with conc. H_2SO_4 for 29 - 30 min. exhibited maximum germination whereas stored seeds (3 months) required

acid treatment of 45 - 50 min duration for maximum germination (Bhagat and Singh, 1995).

Diluted HCl (40%) for 24 h. gave highest germination in ***Pterocarpus santalinus*** (75.8% germination vs 37.5% in control) and ***P. marsupium*** (84.5% vs 38.5% in control) while H_2SO_4 and HNO_3 had little effect on germination (Kalimuthu and Lakshmanan, 1995).

Boiling water immersion for 60 sec. gave highest (86%) germination followed by acid scarification (79%) in ***Sesbania sesben*** as reported by Urmila Jamwal and Dutt, 1995.

Brahmam (1996) reported that hot water (100°C) for 30 or 60 sec. and conc. H_2SO_4 soaking (5-25 min) promoted 77-85% germination in ***Enterolobium cyclocarpum*** and 67-80% in ***Hymenaca courbaril*** seeds. Brahmam ***et al.***(1996) reported that ***Sapindus mukorossi*** and ***S. trifoliatus*** seeds when treated with conc. sulphuric acid or cowdung slurry, stimulated germination to 70-80% in comparison to zero percent in the control.

Prasad and Nautiyal (1996) working with ***Bauhinia racemosa*** seeds observed that mechanical scarification gave 98% germination and hot water gave 68% germination in comparison with 38% in control.

The seeds of ***Cucumis sativus*** gave highest percentage of germination when treated in hot air oven drying at 45°C for 72 hrs. among many pretreatments performed by Suryawanshi ***et al.*** (1996).

In 1997, Choubey ***et al.*** found best result in the seeds of ***Buchanania lanzan*** when treated with 98% H_2SO_4 for 10 min (50% vs 15% in control).

Kundu ***et al.*** (1997) reported that hot water (50°C) treatment for 30 min improved the germination in ***Alstonia scholaris*** seeds (42.4% vs 0.2% in control).

Gagare ***et al.*** (1998) reported that seeds of ***Helicteres isora*** when treated with H_2SO_4 for 20 min gave highest (53.35) germination percentage. In ***Andrographis paniculata*** potassium nitrate (0.5%) for 24 hr. exhibited highest (57.20) germination of seeds.

Mechanical scarification was found to be effective in breaking the seed dormancy in ***Cassia tora*** , ***C. occidentalis*** exhibiting 96 and 82 percent germination, respectively. In ***Amaranthus spinulosus,*** germination was improved by KNO_3 (0.4%) to some extent (60%) as reported by Nalini and Uppar (1998).

Suryawanshi ***et al.***(1998) successfully used diluted Nitric acid (25% and 12.5%) for 10 or 15 min. with the seeds of some medicinal plants viz. ***Cassia angustifolia, Solanum viraum*** and ***Artemisia pallens.***

Das and Thapliyal, (1999) found that mechanical scarification of seeds, giving better germination (93.33 % over 0% in control) in ***Adenanthera pavonina,*** and in ***Gleditsia assamica*** (54% germination over 6.6% in control).

In ***Albizia lebbek,*** scarified seeds with conc. H_2SO_4 followed by soaking them in cow urine for 12 h. gave 70.8% germination over 54.5% in control (Ilango ***et al.***, 1999).

Dharmendra Kumar and Pyare lal (1999) while working with ***Sesbania rostrata*** seeds observed that seeds treated with conc. H_2SO_4 for 30 min. gave

99.3% germination and scrubbing the seeds with sand for two minutes showed 95.7% germination compared with 7.0% in control.

NaOH, KNO_3 and H_2SO_4 were tried in the seeds of ***Santalum album*** as chemical scarification. NaOH did not allow the seeds to germinate irrespective of its concentration and duration of soaking. The seeds soaked in coconut water showed enhanced seed germination by more than two fold over control (Manohar ***et al.***, 1999)

Naidu ***et al.*** (1999) found that in soapnut (***Sapindus trifoliatus***) seeds incubated at 60°C for one to five hours resulted in 84 to 88% germination. Among some chemical scarification such as H_2SO_4, Nitric acid and HCl, sulphuric acid increased germination percentage followed by Nitric and Hydrochloric acids.

In the seeds of ***Cleistanthus callinus***, Sharma ***et al.***(1999 a) found 70% germination of seeds soaking for 24 hours in boiled water. In order of effectiveness, boiled water-treatment was followed by seed treatment with conc. sulphuric acid (10 min soaking).

Terminalia bellerica showed 45% germination in the seeds treated with 10% H_2SO_4 for 10 minutes which was better than control (6% germination) as reported by Sharma ***et al.*** (1999).Acid scarified seeds of ***Acacia nilotica*** gave 82% germination compared to 4% in control (Umarani ***et al.***, 1999).

Seed pretreatment with 5% CMC medium (Carboxyl Methyl Cellulose) was found to enhance germination in ***Acacia catechu*** (60% over 44% in control), ***Acacia nilotica*** (64% over 36% in control) and in, ***Albizia***

procera (60% over 32% in control) by Harsh and Ojha (2000).

Kader and Chacko (2000) found that germination can be enhanced from 2.3 % (untreated) to over 75% either by nicking or by scarifying the seed coat for 20-60 min using 95% conc. sulphuric acid, in the seeds of ***Thespesia populnea.***

Seeds of ***Pterocarpus marsupium*** soaking in 10% H_2SO_4 for 10 min. gave better (68%) germination over control (5%). Boiled water treatment was found inimical for both seed germination and seedling growth (Sharma ***et al.,*** 2000).

The results indicated that 83% of seed germination within 18 days in chironji (***Buchanania lanzan***) can be achieved by mechanical breaking (Shukla and Solanki, 2000).

Gautam and Bhardwaj (2001), while working on the seeds of Ban Oak (***Quercus leucotrichophora***), found that the seeds subjected to cold water treatment for 24 hr. gave 94.89% germination while concentrated sulphuric acid dip for 10 min. gave 93.33% germination. This treatement was proved to be effective in promoting germination over 58.33 % in control.

In ***Caesalpinia sappan*** seeds, better (48%) germination was found in the seeds treated with conc. sulphuric acid for 6 min. by Channegowda ***et al.*** (2001).

Deore ***et al.***(2002) found that acid scarification for 15 min. in the seeds of ***Psorolia corylifolia*** exhibited highest germination (89.00%).

Girase ***et al.***(2002) reported that conc. sulphuric acid treatment for 5

min and hot water (100°C) treatment for 15 min. were found to be effective for breaking dormancy of ***Acacia eburnea*** seeds. The dormancy present in the seeds of ***Acacia auriculiformis*** and ***A. tortilis*** could be overcome by mechanical scarification (rubbing polish paper) and conc. sulphuric acid treatment for 15 min., respectively.

Malarkodi ***et al.*** (2002) reported that chemical scarification with KNO_3 and thiourea break the dormancy of seeds of ***Tridax.*** Similarly, 1% KNO_3 treatment for 1 hr. gave better germination in the seeds of ***Naiuruvi*** (Natarajan ***et al.***, 2002).

Raja and Srimathi (2002) found that seeds treated with acid (1 min) + KNO_3 (2%) resulted in high percentage of seed germination in ***Echinocloa crusaalli*** and ***E. Clona***.

In the seeds of ***Cassia sericea,*** Uppar ***et al.*** (2002) found that hot water treatment for 5 min. gave maximum germination (88%) as compared to control (14.0%). Acid scarification for 3 min also recorded maximum germination (87%).

Recently, Singh ***et al.*** (2002) have reported that predrying at 45°c for 10 days gave 86-95% germination in ***Arachis hypogea.*** Working with the seeds of ***Acacia nilotica,*** Vankatesh ***et al.*** (2002) observed 76% germination (18% in control) after 60 minute acid scarification followed by water soaking.

CHAPTER - IV

MATERIALS AND METHODS

MATERIALS AND METHODS

SELECTION OF TREES :

Due to their multipurpose use and well adapted to the climate of the study area, following trees were selected for present study.

1. *Acacia auriculiformis* (Benth.) A. Cunn.
2. *Acacia catechu* willd.
3. *Acacia nilotica* (Benth.) Brenan.
4. *Albizia lebbek* Benth.
5. *Cassia fistula* Linn.
6. *Cassia siamea* Lam.
7. *Delonix regia* (Boj) Rafin
8. *Leucaena leucocephala* (Lam.) de Wit.
9. *Parkinsonia aculeata* Linn.
10. *Pithecellobium dulce* Benth.
11. *Prosopis juliflora* (Sw) Dc.

Most of the seeds were collected form standing trees at the seeding time. Seeds were also obtained from (Table 1) :

1. From Seed Agencies - Seeds were purchased by seed suppliers.

2 Forest Department - Seeds of some species were obtained from forest department where they are used to raise the nursaries.

3. Seeds of many species, stored in the laboratory where research work is being done, were also obtained.

Table 1: Details of collection of different forest tree seeds.

Lot No.	Species	Year of collection	Collected From	
1.	*Acacia auriculiformis* #	1989	Seed Agency	Jalaun
2.	*Acacia catechu* *#	1983	Standing trees	Sagar
3.	*Acacia catechu* * #	1989	Seed Agency	Jalaun
4.	*Acacia catechu* *	2000	Forest department	Jhansi
5.	*Acacia catechu*	2000	Seed Agency	Jalaun
6.	*Acacia catechu*	2001	Seed Agency	Jhansi
7.	*Acacia catechu*	2001	Standing trees	Jhansi
8.	*Acacia nilotica* #	1989	Seed Agency	Jalaun
9.	*Acacia nilotica*	2000	Forest department	Jhansi
10.	*Acacia nilotica* *	2000	Seed Agency	Jalaun
11.	*Acacia nilotica*	2001	Seed Agency	Jhansi
12.	*Acacia nilotica* *	2002	Standing trees	Hamirpur
13.	*Albizia lebbek* * #	1983	Standing trees	Tikamgarh
14.	*Albizia lebbek* * #	1983	Standing trees	Hamirpur
15.	*Albizia lebbek* * #	1989	Seed Agency	Jalaun
16.	*Albizia lebbek*	2000	Seed Agency	Jalaun
17.	*Albizia lebbek*	2001	Standing trees	Hamirpur
18.	*Albizia lebbek*	2002	Standing trees	Hamirpur
19.	*Albizia procera* * #	1989	Seed Agency	Jalaun
20.	*Cassia fistula* * #	1978	Forest department	Balaghat
21.	*Cassia fistula* * #	1982	Seed Agency	Dehradun
22.	*Cassia fistula* * #	1983	Standing trees	Sagar
23.	*Cassia fistula*	2001	Standing trees	Hamirpur
24.	*Cassia fistula*	2001	Standing trees	Jhansi

25.	*Cassia fistula*	2002	Standing trees	Hamirpur
26.	*Cassia siamea*	2000	Seed Agency	Jalaun
27.	*Delonix regia* * #	1989	Seed Agency	Jalaun
28.	*Delonix regia*	2001	Standing trees	Hamirpur
29.	*Delonix regia* *	2002	Standing trees	Hamirpur
30.	*Leucaena leucocephala*	2000	Forest department	Jhansi
31.	*Leucaena leucocephala*	2001	Standing trees	Hamirpur
32.	*Leucaena leucocephala*	2001	Seed Agency	Jhansi
33.	*Parkinsonia aculeata* #	1989	Seed Agency	Jalaun
34.	*Pithecellobium dulce* * #	1989	Seed Agency	Jalaun
35.	*Pithecellobium dulce* #	2001	Seed Agency	Jhansi
36.	*Pithecellobium dulce* *	2002	Standing trees	Hamirpur
37.	*P. samen* * #	1989	Seed Agency	Jalaun
38.	*Prosopis juliflora* * #	1989	Seed Agency	Jalaun
39.	*Prosopis juliflora*	2000	Seed Agency	Jalaun
40.	*Prosopis juliflora*	2001	Seed Agency	Jhansi
41.	*Prosopis juliflora*	2002	Seed Agency	Jhansi
42.	*Prosopis juliflora* *	2002	Standing trees	Hamirpur

* = Detailed study was not done

\# = Old seeds stored in the laboratory

SEED COLLECTION :

Details about seed collection of different trees are given in Table 1. Ripen pods of ***Acacia nilotica, Albizia lebbek, Cassia fistula, Delonix regia, Leucaena leucocephala*** and ***Prosopis juliflora*** were plucked from the standing trees while some pods and seeds of ***Albizia lebbek*** and ***Leucaena leucocephala***

Plate No. 1 : Plucking the pods from the tree by folding long handled (20 feet long) sickle..

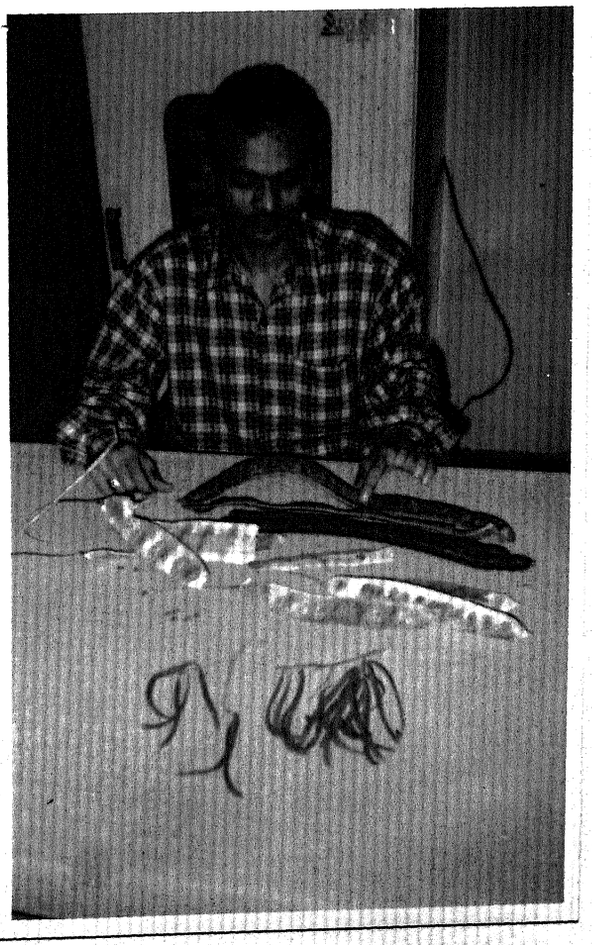


Plate No. 2 :

Extraction of seeds from the pods of

1. ***Delonix regia***
2. ***Cassia fistula***
3. ***Albizia lebbek***
4. ***Prosopis juliflora***

were also collected from the ground. Fresh seeds were collected in the crop year of 2000, 2001 and 2002.

EXTRACTION OF SEEDS :

All the collected pods brought to the laboratory and seeds were extracted from them. Seeds of ***Acacia nilotica, Albizia lebbek, Leucaena leucocephala*** and ***Prosopis juliflora*** were easily extracted from the pods. In ***Cassia fistula,*** light hammer strokes were applied to broken the pods to extract the seeds. In ***Delonix regia*** heavy hammer strokes were applied many times to break the hard pods. Extraction of seed was done by taking out them one by one from their locules.

SEED STORAGE :

Extracted seeds were dried in the shade for a few days and later on in the sun light before keeping them in storage. They were stored in glass bottles tightly closed and placed in almirah in the laboratory. A small amount of seeds of each species was stored in refrigerator (5°C) in glass bottles.

After 6 and 12 month storage, performance of these stored seeds was noticed applying the most suitable pretreatment on them. Seeds stored in glass bottles at room temperature served as the control.

All the pretreatment were performed with seeds stored in glass bottles at room temperature. Care was taken to avoid moisture entry inside the bottles.

SEED GERMINATION :

Resumption of active growth in embryo resulting in the rupture of seed coat and emergence of young plant is known as germination. According

to International Seed Testing Association (ISTA, 1976), germination in a laboratory test is the emergence and development of those essential structures from seed embryo which indicate the ability to develop into a normal plant under controlled conditions.

Seeds were germinated in the seed germinator in controlled conditions (Temperature 28°C ± 2°C and relative humidity about 95%). For each germination test usually one hundred and sometimes 50 seeds were taken in each replicate and usually four and sometimes two such replicates were taken for studies.

Seed were germinated on the three layered moistened sheet of filter paper which was spread on germination trays and kept moistened throughout the experiment. In the case of smaller seeds or less seeds, studies were conducted in petriplates, the bottom of which were lined by three layered moistened sheet of filter paper. Spacing between seeds was uniform and enough apart to prevent the coming - up seedling from touching each other (Anon, 1976).

PRETREATMENTS TO OVERCOME SEED DORMANCY :

Following pretreatments were performed with the seeds of various species.

1. CHEMICAL TREATMENT :

Chemicals used to soften the seed coat of various trees included Potassium nitrate, Potassium dichromate, Thiourea, Sodium nitrite and cattle urine. Seeds were thoroughly washed with water after each treatment and then kept for soaking in water for 20 hrs at room temperature. Number of imbibed

and hard seeds was noted and seeds were kept on the filter paper spread on germination trays of seed germinator. After 15 days, germinated, hard and dead seeds were counted. Time of soaking and concentration of various chemicals is given below -

a) **POTASSIUM NITRATE (KNO_3) :**

Seeds were soaked in 10% solution of KNO_3 for 10 and 20 hours.

b) **POTASSIUM DICHROMATE ($K_2Cr_2O_7$) :**

Seeds were soaked in 5% solution of Potassium dichromate for 10 and 20 hours.

c) **THIOUREA (H_2NCSNH_2) :**

Seeds were soaked in 5% solution of thiourea for 10 and 20 hours.

d) **SODIUM NITRITE ($NaNO_2$) :**

Seeds were soaked in 5% solution of sodium nitrite for 10 and 20 hrs.

e) **CATTLE URINE:**

Seeds were soaked in cattle urine for 10 and 20 hours.

2. ACID SCARIFICATION :

(a) **HYDROCHLORIC ACID (HCl) :**

Seeds of ***Delonix regia*** were kept in concentrated Hydrochloric acid for 60, 120 and 180 minutes.

(b) **NITRIC ACID (HNO_3) :**

Seeds of ***Delonix regia*** were kept in concentrated Nitric acid for 60, 120 and 180 minutes.

(c) **SULPHURIC ACID (H_2SO_4) :**

H_2SO_4 was used in 3 ways -

i) **CONCENTRATED (98%) SULPHURIC ACID :**

Seeds were kept in a plastic bottle having small pores on the bottom and on the lower portion. These bottles with seeds were dipped in beaker containing conc. sulphuric acid. During the period seeds were continuously stirred by glass rod. After the desired duration, plastic bottles were taken out of the acid and seeds were washed throughly in running water in order to free the seed coat from sulphuric acid. Time allowed in conc. H_2SO_4 was 1, 2, 3, 5, 10, 15, 30, 45, 60 and 90 min. and 3, 6 & 7 hours.

ii) DILUTED (50%) SULPHURIC ACID :

Seeds were kept in diluted (50%) Sulphuric acid as above for the duration of 2, 5, 10, 30, 60, 90 and 180 minutes. After scarification seeds were washed in running tap water.

III) DILUTED (10%) SULPHURIC ACID :

Seeds were kept in 10% H_2SO_4 for 10, 20 and 30 hours and then washed in running tap water.

3. PHYSICAL PRETREATMENTS :

Some physical pretreatments were performed with the seeds. These include dry heat, hot water, boiling water and shock treatments.

(A) DRY HEAT TREATMENT :

Seeds were kept open in petridishes in the oven. Temperature of oven and duration of treatment was as follows -

i) 40°C for 5, 10 and 15 days.

ii) 60°C for 5, 10 and 15 days.

iii) 80°C for 5, 10 and 15 days.

(B) HOT WATER TREATMENT :

Seeds were kept in beaker with water and placed in oven at -

i) 40°C for 12 and 24 hours

ii) 60°C for 5, 7 and 20 hours

iii) 80°C for 4, 11 and 20 hours.

(C) BOILING WATER TREATMENT :

Seeds were treated with boiling water in following ways -

i) Water was heated upto boiling point and then seeds were dipped into the boiled water and then separated and kept for soaking.

ii) Water was kept on a heater. When it started boiling, seeds were dipped in it for 5, 10, 20 and 30 seconds ; 1, 2 and 5 minutes. Wire screen was used to dip the seeds in boiling water. After the duration seeds were soaked for 20 hrs. in tap water and kept for germination.

(D) SHOCK TREATMENT :

Seeds were kept in a wire screen, dipped in boiling water and then in ice water alternately for different duration and different times.

i) 5 seconds in boiling water then 5 seconds ice water for 1, 2 and 5 times.

ii) 10 seconds in boiling water then 10 seconds in ice water for 1, 2 and 5 times.

4. MECHANICAL SCARIFICATION :-

SEEDS WERE SCARIFIED MECHANICALLY BY FOLLOWING METHODS :-

(a) Smaller seeds were obrassed on an iron paper (filing).

(b) Larger seeds were obrassed on a file (filing).

(c) Small portion of testa opposite to micropylar end was cut with the help of special scissors (nicking).

(d) Same method as (c) done by nail cutter (clipping).

(e) Hot iron rod of souldering iron was touched to the flat surface of seed (Burning)

5. CONTROL :

Seeds were soaked in tap water at room temperature for 20 hours.

6. PRETREATMENT OF STORED SEEDS :

Some seeds were taken after one year storage in various conditions and most suitable pretreatment was applied on them to see the effect of storage on dormancy.

7. STORAGE OF PRETREATED SEEDS :

Most effective pretreatment was applied to the seeds of some species and such seeds were stored in the laboratory. After the storage of 6 and 12 month these seeds were tested for germination.

8. TETRAZOLIUM TEST FOR VIABILITY :

The viability of all the ungerminated (hard) seeds was determined at the end of each germination experiment after each pretreatment by TTC test.

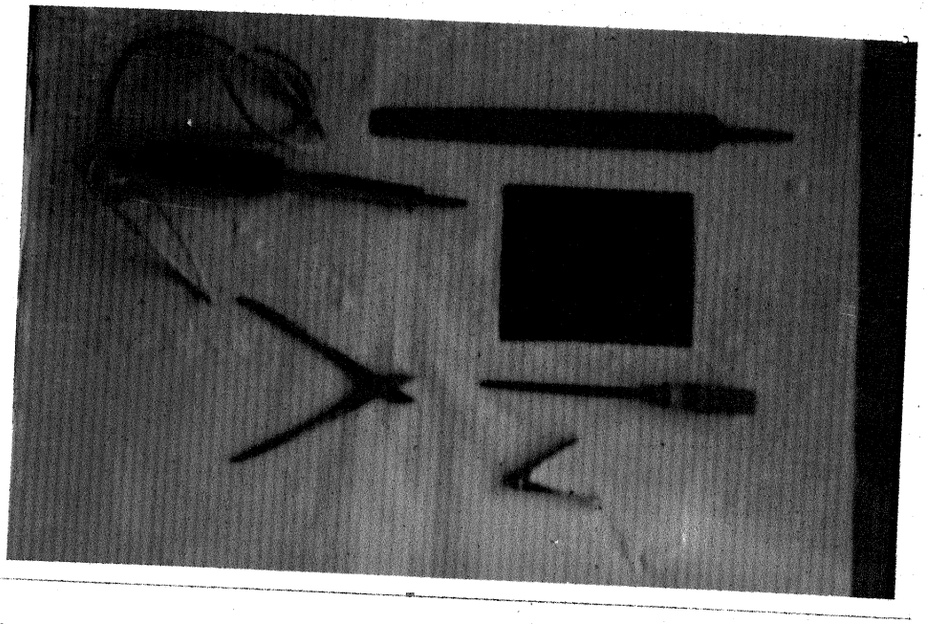


Plate No. 3 : Various instruments for Mechanical scarification .

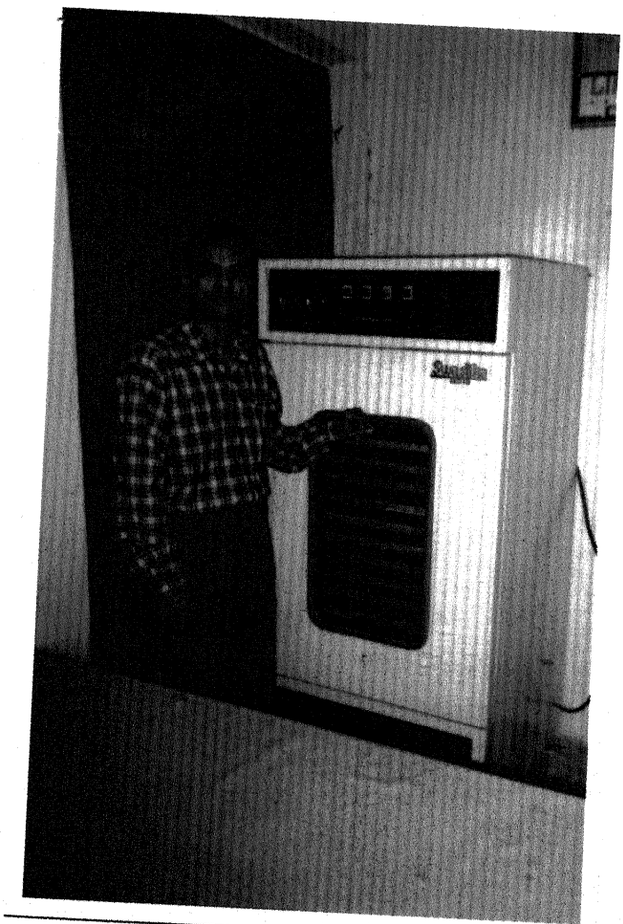


Plate No. 4 : Keeping the seeds for germination in seed germinator.

The testa of each hard seed was nicked or filed at the end opposite the radicle. Seeds were then soaked for 24 hours at room temperature. After imbibition, the seed coat and the geletinous endosperm material surrounding the embryo were removed. These embryos were immersed in 0.1% solution of 2,3,5 - triphenyl tetrazolium chloride at 35°C and kept overnight. After the staining, solution was drained off and the embryos were rinsed many times with fresh water. The topographical staining pattern of the embryos was evaluated for each seed and used to place the seed into one of the following viability classes (Table - 2) (Babeley and Kandya, 1989 ; Todd - Bockarie ***et al.***, 1993).

Table 2: Topographical stain evaluation classes

No.	Description	Viability Class
1.	Uniform red staining of full embryo	Germinable
2.	Major part of embryo stained except small portion of cotyledon opposite to radicle	Germinable
3.	Pale pink staining of full embryo	Weak germinable
4.	Cotyledons < 50% unstained	Weak germinable
5.	Radicle unstained or damaged	Non - germinable
6.	Light pink staining of the embryo	Non - germinable
7.	Embryo stained abnormally dark - red	Non - germinable
8.	Embryo insect attacked	Non - germinable
9.	No staining	Non - germinable

9. SEED VIGOUR :

Seed vigour is the sum total of all those properties in seed which, upon planting, result in rapid and uniform production of healthy seedlings under a wide range of environment.

Seed vigour test is a laboratory method to evaluate seed vigour. The object of a vigour test is to differentiate a range of quality levels, e.g., high , medium and low - vigour seeds. Thus, seed lots with similar germination in the laboratory may have difference in their vigour which is reflected by early germination of good seed lot. During the present study evaluation of seed vigour was done by following methods -

a - By measuring Germination Velocity Index (GVI)

b - By formation of Vigour Classes of seedlings.

(a) Germination Volocity Index (GVI) = During germination of seeds in laboratory, daily counts of the newly germinated seeds were made and GVI was calculated by (Agrawal, 1980).

$$GVI = \frac{\text{Daily counts of newly germinated seeds}}{\text{Number of days of germination}}$$

(b) SEEDLING VIGOUR CLASSES :

Seedling of each species were classified into 6 vigour classes according to their growth performance (Babeley, 1985).

Vigour class 1 = Fully developed seedlings with seed coat completely shed, cotyledons fully extended, epicotyl visible.

Vigour class 2 = Well developed seedlings with seed coat almost completely shed, cotyledons spreading.

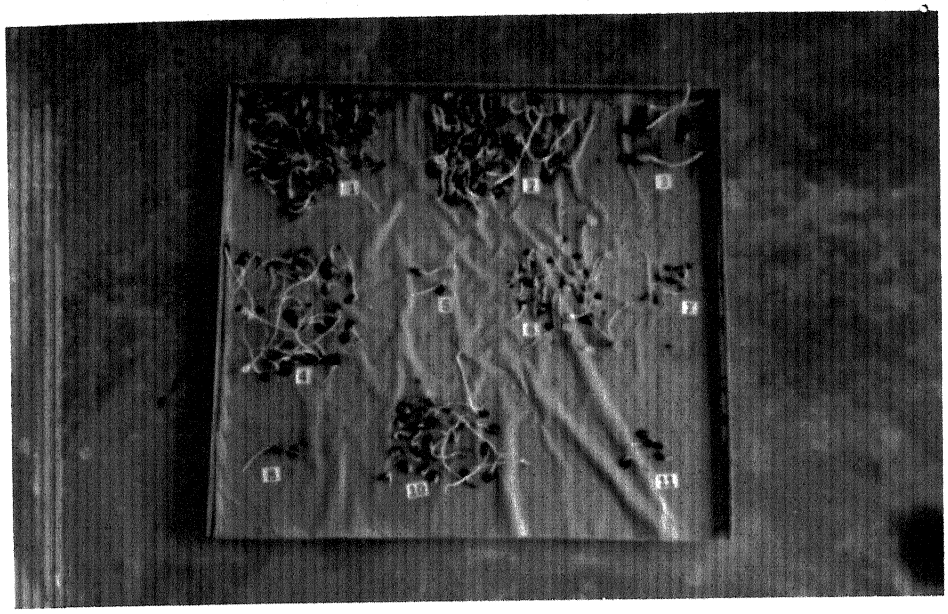


Plate No. 5 : Seedlings of various species

1. *Acacia nilotica*
2. *Cassia fistula*
3. *Delonix regia*
4. *Leucaena leucocephala*
5. *Parkinsonia aculeata*
6. *Prosopis juliflora*
7. *Acacia auriculiformis*
8. *Acacia catechu*
10. *Albizia lebbek*
11. *Cassia siamea*

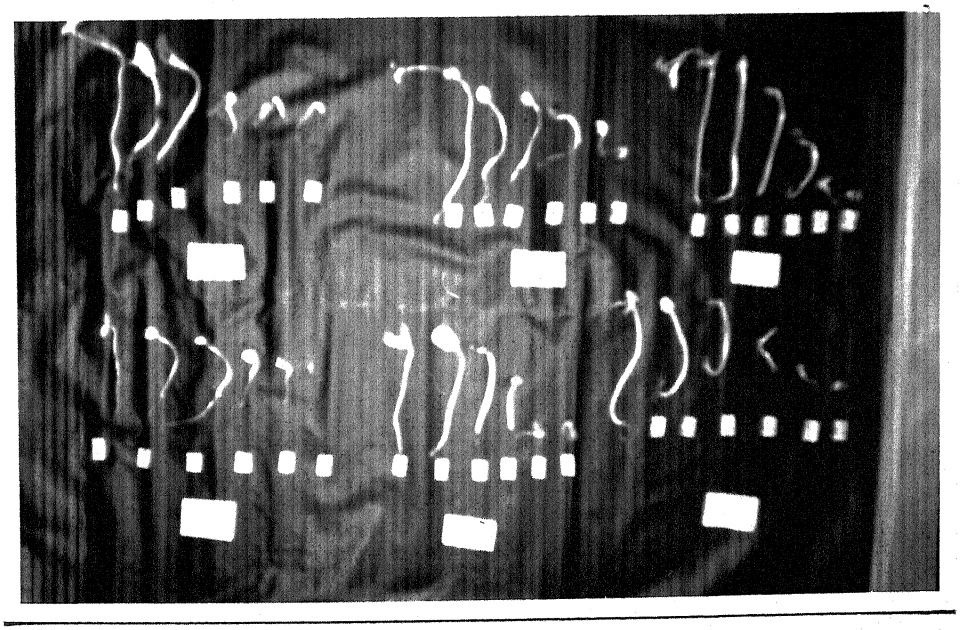


Plate No. 6 : Vigour classes (1 to 6) of seedlings of various species.

1. *Delonix regia*
2. *L. Leucocephala*
3. *Albizia lebbek*
4. *Prosopis juliflora*
5. *Cassia fistula*
6. *Acacia nilotica*

Vigour class 3 = Well developed seedlings with seed coat partly shed.

Vigour class 4 = Moderately developed hypocotyl with cotyledons barely or not yet visible.

Vigour class 5 = Raised hypocotyl shorter than vigour class 4 with complete seed coat on.

Vigour class 6 = Radicle emerged with little hypocotyl visible.

EXPERIMENTATION :

Various pretreatments were performed with the seeds of all the species in three successive rounds. Each round took about 6-8 month period to be completed. Various pretreatments taken in each round were - (Table 3)

Round 1 - Water soaking (40°C) for various duration.

Dry heat (40°, 60° and 80°C) for various duration.

Chemical treatment (Various chemicals).

Mechanical scarification (Filing).

Control

Round 2 - Concentrated acid (HCl, HNO_3 and H_2SO_4)

Diluted (50% and 10%) H_2SO_4

Mechanical scarification(Nicking and Burning)

Control

Round 3 - Hot water treatment

Boiling water treatment

Shock treatment

Mechanical scarification (Clipping)

Control

IMBIBITION :

After each pretreatment, seeds were soaked in tap water at room temperature to see the effect of treatment on imbibition of seeds. After 20 hours all the seeds were taken out and kept in seed germinator for germination and vigour studies.

Table 3 : Details of experimentation conducted in three rounds

Species	Lot No.	Rounds of treatments							Common for all treatments	
		1			2	3				
		WS	DH	CT	AT	HWT	BWT	ST	MS	C
A. auriculiformis	1	*	*	*	*	*	*	*	*	*
A. catechu	2								*	*
A. catechu	3								*	*
A. catechu	4								*	*
A. catechu	5	*	*	*					*	*
A. catechu	6			*		*			*	*
A. catechu	7				*				*	*
A. nilotica	8	*	*	*					*	*
A. nilotica	9	*	*	*	*				*	*
A. nilotica	10								*	*
A. nilotica	11			*		*	*	*	*	*
A. nilotica	12								*	*
Albizia lebbek	13								*	*
A. lebbek	14								*	*
A. lebbek	15								*	*
A. lebbek	16	*	*	*					*	*
A. lebbek	17				*				*	*
A. lebbek	18					*	*	*	*	*

Species	Lot No.	Rounds of treatment							Common for all	
		WS	DH	CT	AT	HWT	BWT	ST	MS	C
Albizia procera	19								*	*
Cassia fistula	20								*	*
Cassia fistula	21								*	*
Cassia fistula	22								*	*
Cassia fistula	23	*	*	*		*			*	*
Cassia fistula	24				*				*	*
Cassia fistula	25					*	*	*	*	*
Cassia siamea	26	*	*	*	*	*	*	*	*	*
Delonix regia	27								*	*
Delonix regia	28	*	*	*	*	*	*	*	*	*
Delonix regia	29								*	*
L. leucocephala	30	*	*	*		*			*	*
L. leucocephala	31				*				*	*
L. leucocephala	32			*		*	*	*	*	*
Parkinsonia aculeata	33	*	*	*	*	*	*	*	*	*
Pithecellobium dulce	34								*	*
Pithecellobium dulce	35			*	*	*			*	*
Pithecellobium dulce	36								*	*
Pithecellobium samen	37								*	*
Prosopis juliflora	38								*	*
Prosopis juliflora	39	*	*	*		*	*	*	*	*
Prosopis juliflora	40	*	*	*	*				*	*

WS = Water soaking ; DH = Dry heat treatment ; CT = Chemical treatment ;

AT = Acid treatment ; HWT = Hot water treatment ; ST = Shock treatment ;

MS = Mechanical scarification ; C = Control.

CHAPTER - V

OBSERVATIONS AND INTERPRETATIONS

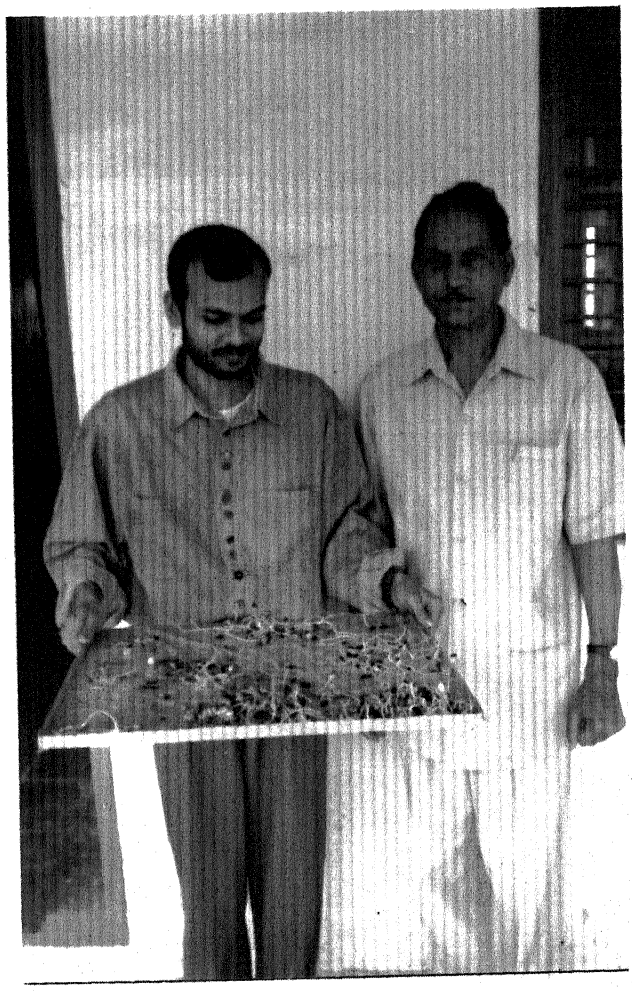


Plate No. 6 : 15 days old seedlings of some species to be categorized in vigour classes.

OBSERVATIONS AND INTERPRETATIONS

OBSERVATIONS AND INTERPRETATIONS :

Pretreatment is a "pre - sowing - treatment" carried out in order to enhance rapid and uniform germination of seed sown in the nursery, field or for testing.

Effect of various pretreatments on the imbibition and germination of different tree species are given in Tables (4 to 39). All the treatments were performed in three successive rounds. Experiments of one round are given in one table for each species/seed lot except a few. Thus, three tables were required to complete one seed lot/species. Results are given plant wise i.e. all the experiments were discussed one by one for one species/ seed lot.

Acacia auriculiformis

HEAT TREATMENT :

As shown in Table 4, soaking in water at 40°C and dry heat treatment (40°C, 50°C and 80°C) for 5, 10 and 15 days duration could not improve the permeability of hard coated seed of ***A. auriculiformis***. Most of the seed remained hard after 20 hrs. soaking in water following each pretreatment. Percent germination was lower than that of control (9 to 16% Vs 21 % in control). A good amount of seeds (56 to 62%) remained hard while some seeds were found to be dead at the end of the experiment.

Table 4 : Percentage of imbibed, hard, germinated and dead seeds of *A. auriculiformis* as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	13	87	25	48	27
2.	Seeds soaked in water (40°C) for 24 hrs.	17	83	21	56	23
3.	Seeds kept in oven at 40°C for 5 days	11	89	14	27	59
4.	Seeds kept in oven at 40°C for 10 days	13	87	15	29	56
5.	Seeds kept in oven at 40°C for 15 days	17	83	15	35	50
6.	Seeds kept in oven at 60°C for 5 days	23	77	16	23	61
7.	Seeds kept in oven at 60°C for 10 days	25	75	15	25	60
8.	Seeds kept in oven at 60°C for 15 days	27	73	13	29	58
9.	Seeds kept in oven at 80°C for 5 days	23	77	13	25	62
10.	Seeds kept in oven at 80°C for 10 days	26	74	9	31	60
11.	Potassium nitrate (10%) for 10 hrs	27	73	7	67	26
12.	Potassium nitrate (10%) for 20 hrs	33	67	8	75	17
13.	Potassium dichromate (5%) for 10 hrs	9	91	14	27	59
14.	Potassium dichromate (5%) for 20 hrs	11	89	13	32	55
15.	Sodium nitrite (5%) for 10 hrs.	14	86	15	29	56
16.	Sodium nitrite (5%) for 20 hrs.	17	83	17	31	52
17.	Thiourea (5%) for 10 hrs.	13	87	4	35	61
18.	Thiourea (5%) for 20 hrs.	15	85	5	40	55
19.	Cattle urine for 10 hrs.	27	73	7	54	39
20.	Cattle urine for 20 hrs.	33	67	9	60	31
21.	Mechanical scarification (Filing)	100	--	27	73	--
22.	Control	21	79	24	36	40

CHEMICAL TREATMENT :

According to Table 4, soaking the seeds in different chemicals (10 % KNO_3, 5% $K_2Cr_2O_7$, 5% $NaNO_2$, 5% thiourea and cattle urine) for 10 and 20 hrs. duration did not improve the permeability of seed coat (1% to 30 %). Germination percentage was lower (4% to 17%) than that of control (24%). A good amount of seeds became dead (27% to 75%). It may be due to the lethal effect of chemicals. Some seeds remained hard at the end of the treatment.

MECHANICAL SCARIFICAION :

Filing gave the best results (100% imbibition in 20 hrs.). Highest germination percentage was obtained (27%) by this treatment, leaving no hard seed at the end of the treatment.

ACID TREATMENT :

As shown in Table 5, forty five to sixty min treatment with acid gave very good germination (31 - 40% Vs 25% in control) in ***Acacia auriculiformis*** seeds.When the duration of treatment was increased from 60 min, the germination came down and the number of dead seed increased (60% Vs 52% in control). The duration less than 30 minute was not effective for germination (13 - 21 % Vs 25% in control) and some seeds remained hard at the end of the experiment.

Diluted (50% and 10%) H_2SO_4 was not found to be effective for softening the seed coat. Many seeds remained hard (30 - 62% Vs 23% in control) and rest of the seeds became dead leaving only some seeds germinable (9 - 23 % germination Vs 25% in control).

Table 5 : Percentage of imbibed, hard, germinated and dead seeds of *A.auriculiformis* as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
23.	Concentrated (98%) H_2SO_4 for 1 min.	41	59	13	43	44
24.	Concentrated (98%) H_2SO_4 for 2 min.	51	49	15	48	37
25.	Concentrated (98%) H_2SO_4 for 3 min.	53	47	16	53	31
26.	Concentrated (98%) H_2SO_4 for 5 min.	55	45	17	56	27
27.	Concentrated (98%) H_2SO_4 for 10 min.	63	37	20	58	22
28.	Concentrated (98%) H_2SO_4 for 15 min.	65	35	21	59	20
29.	Concentrated (98%) H_2SO_4 for 30 min.	69	31	27	56	17
30.	Concentrated (98%) H_2SO_4 for 45 min.	73	27	31	54	15
31.	Concentrated (98%) H_2SO_4 for 60 min.	77	23	40	49	11
32.	Concentrated (98%) H_2SO_4 for 90 min.	81	19	28	60	12
33.	Diluted (50%) H_2SO_4 for 2 min.	9	91	12	29	59
34.	Diluted (50%) H_2SO_4 for 5 min.	11	89	13	31	56
35.	Diluted (50%) H_2SO_4 for 10 min.	15	85	15	32	53
36.	Diluted (50%) H_2SO_4 for 30 min.	21	79	17	34	49
37.	Diluted (50%) H_2SO_4 for 60 min.	28	72	20	43	37
38.	Diluted (50%) H_2SO_4 for 90 min.	31	69	22	42	36
39.	Diluted (50%) H_2SO_4 for 180 min.	67	33	23	47	30
40.	Diluted (10%) H_2SO_4 for 10 hrs.	26	74	9	29	62
41.	Diluted (10%) H_2SO_4 for 20 hrs.	37	63	12	32	56
42.	Diluted (10%) H_2SO_4 for 30 hrs.	45	55	16	36	48
43.	Mechanical scarification(Nicking)	100	--	25	75	--
44.	Mechanical scarification (Burning)	100	--	20	80	--
45.	Control	21	79	23	53	24

MECHANICAL SCARIFICATION :

Hundred percent imbibition was shown by mechanical scarification. Nicking gave better germination (25%) than that of control (23%). But poor germination was found by burning (20%) as its injurious effect on seeds.

HOT WATER TREATMENT :

As revealed by Table 6, the seeds of ***A. auriculiformis*** treated with hot water (60°C) for 5 hours gave second highest germination (44 % Vs 21 % in control). Seven hour soaking at the same temperature also gave good (38%) germination. Other temperature and durations gave similar results to that of control. Many seeds were found dead while some remained hard after the experiment.

BOILING WATER TREATMENT :

This treatment gave better results than any other treatment. Ten second soaking of seeds in boiling water gave highest (46%) germination.Twenty seconds, five seconds duration also gave excellent results (43% and 41% respectively Vs 21% in control) seed dipped in boiling water, kept in it for 5, 20 and 30 seconds also gave good results (40%, 41%, 43% and 38%, respectively). Imbibition was below 40% after 20 hours soaking the seed in all the treatments showing that seed coat of this species is well tolerated to higher temperature.

SHOCK TREATMENT :

Alternating dipping the seeds in boiling and ice water for 5 and 10 seconds gave better results than that of control. Five seconds for 1 time and 10 sec. for 5 times surprisingly gave better results than that by other duration.

Table 6 : Percentage of imbibed, hard, germinated and dead seeds of *A. auriculiformis* as affected by hot water, boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
46.	Hot water soaking (60°C) for 5 hours.	20	80	44	52	4
47.	Hot water soaking (60°C) for 7 hours.	31	69	38	60	2
48.	Hot water soaking (60°C) for 20 hours.	37	63	21	76	3
49.	Hot water soaking (80°C) for 4 hours.	33	67	25	68	7
50.	Hot water soaking (80°C) for 11 hours.	37	63	21	72	7
51.	Hot water soaking (80°C) for 20 hours.	35	65	19	76	5
52.	Boiling water dipping	21	79	40	51	9
53.	Boiling water soaking for 5 sec.	24	76	41	52	7
54.	Boiling water soaking for 10 sec.	30	70	45	50	5
55.	Boiling water soaking for 20 sec.	32	68	43	53	4
56.	Boiling water soaking for 30 sec.	33	67	38	59	3
57.	Boiling water soaking for 1 min.	35	65	33	66	1
58.	Boiling water soaking for 2 min.	37	63	30	69	1
59.	Boiling water soaking for 5 min.	39	61	28	72	--
60.	Boiling water/ice water for 5 sec.-1 time	28	72	31	59	10
61.	Boiling water/ice water for 5 sec.-2 times	23	77	26	66	8
62.	Boiling water/ice water for 5 sec.-5 times	19	81	20	73	7
63.	Boiling water/ice water for 10 sec.-1 time	27	73	21	55	24
64.	Boiling water/ice water for 10 sec-2 times	21	79	27	66	7
65.	Boiling water/ice water for 10 sec-5 times	14	86	32	60	8
66.	Mechanical scarification (Clipping)	100	--	25	75	--
67.	Control	23	77	21	53	26

MECHANICAL SCARIFICATION :

Clipping gave slightly higher germination (25% Vs 21% in control) while all the seeds were imbibed. It seems that embryos of some seeds get damaged during scarification making them non - germinable.

Acacia catechu (Lot No - 5):

As indicated in Table 7, seeds of ***A. catechu*** gave 25% germination in control while some of them got injured during filing reducing the germination (18%). No chemical and any treatment of dry heat could initiate the germination of this seed lot (0% germination). Many seeds remained hard at the end of the experiment showing that hard seed coat is not related to viability.

Acacia catechu (Lot no. 6):

CHEMICAL TREATMENT :

As given in Table 8, various chemicals were not found to be effective and germination was not better than that of control (5 - 11% Vs 11% in control). Number of hard seeds remaining at the end of experiment was more when seeds were treated with $K_2Cr_2O_7$ (29 - 32% Vs 2% in control).

HOT WATER TREATMENT :

Germination was found to be poor in 5 to 7 hrs. duration of 60°C treatment (5 - 9% Vs 1% in control), while 60°C for 20 hrs. and 80°C for all the durations badly affected the seeds making all of them non - viable.

Table 7 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia catechu* (Lot no. 5) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C)for 12 hours	59	41	--	91	9
2.	Seeds soaked in water (40°C)for 24 hours	99	1	--	100	--
3.	Seeds kept in oven at 40°C for 5 days	57	43	--	61	39
4.	Seeds kept in oven at 40°C for 10 days	61	39	--	65	35
5.	Seeds kept in oven at 40°C for 15 days	69	31	--	72	28
6.	Seeds kept in oven at 60°C for 5 days	60	40	--	67	33
7.	Seeds kept in oven at 60°C for 10 days	65	35	--	80	20
8.	Seeds kept in oven at 60°C for 15 days	71	29	--	83	17
9.	Seeds kept in oven at 80°C for 5 days	63	37	--	68	32
10.	Seeds kept in oven at 80°C for 10 days	68	32	--	73	27
11.	Potassium nitrate (10%) for 10 hrs.	69	31	--	81	19
12.	Potassium nitrate (10%) for 20 hrs.	75	25	--	93	7
13.	Potassium dichromate (5%) for 10 hrs.	76	24	--	78	22
14.	Potassium dichromate (5%) for 20 hrs.	80	20	--	92	8
15.	Sodium nitrite (5%) for 10 hrs.	74	26	--	79	21
16.	Sodium nitrite (5%) for 20 hrs.	77	23	--	91	9
17.	Thiourea (5%) for 10 hrs.	60	40	--	81	19
18.	Thiourea (5%) for 20 hrs.	69	31	--	89	11
19.	Cattle urine for 10 hrs.	80	20	--	94	6
20.	Cattle urine for 20 hrs.	85	15	--	100	--
21.	Mechanical scarification (Filing)	100	--	18	82	--
22.	Control	57	43	25	40	35

Table 8 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia catechu* (Lot no. 6)as affected by chemical and hot water pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Potassium nitrate (10%) for 10 hrs.	84	16	6	91	3
2.	Potassium nitrate (10%) for 20 hrs.	87	13	5	93	2
3.	Potassium dichromate (5%) for 10 hrs.	78	22	10	70	20
4.	Potassium dichromate (5%) for 20 hrs.	80	20	9	72	19
5.	Thiourea (5%) for 10 hrs.	75	25	6	89	5
6.	Thiourea (5%) for 20 hrs.	79	21	4	93	3
7.	Sodium nitrite (5%) for 10 hrs.	63	37	5	88	7
8.	Sodium nitrite (5%) for 20 hrs.	65	35	5	91	4
9.	Cattle urine for 10 hrs.	61	39	11	81	8
10.	Cattle urine for 20 hrs.	60	40	10	87	3
11.	Hot water soaking (60°C) for 5 hrs.	95	5	9	91	--
12.	Hot water soaking (60°C) for 7 hrs.	99	1	5	95	--
13.	Hot water soaking (60°C) for 20 hrs.	100	--	--	100	--
14.	Hot water soaking (80°C) for 4 hrs.	97	3	--	100	--
15.	Hot water soaking (80°C) for 11 hrs.	100	--	--	100	--
16.	Hot water soaking (80°C) for 20 hrs.	100	--	--	100	--
17.	Mechanical scarification (Filing)	100	--	32	68	--
18.	Control	13	87	11	87	2

MECHANICAL SCARIFICATION :

Filing gave 100% imbibition out of which 32% seeds germinated. This was the best performance given by any treatment.

This seed lot showed poor germination percentage and it seems that the seeds may be of poor quality. It is also possible that the seed supplier had cleared his old stock of seeds or poor storage condition is in his godown deteriorated many seeds.

Acacia catechu (Lot No. 7):

ACID TREATMENT :

As shown in Table 9, five to ten minute soaking of seeds in conc. (98%) H_2SO_4 gave very good germination (73 - 75% Vs 31 % in control). All the treated seeds imbibed within 20 hours leaving no hard seed. Some seeds remained hard when duration was less than 5 minute. Injurious effect of acid was shown as seeds started becoming dead, when duration of acid was more i.e. 15 - 45 minute.

Dilute (50%) H_2SO_4 was found to be effective when seeds were treated for 30 - 60 minute duration (69 - 71 % Vs 39% in control). As the duration was increased, number of imbibed seeds also increased. No seed remained hard after 90 minute treatment but the number of dead seeds increased (42% Vs 20 % in control).

Duration of 30 hours soaking the seeds in dilute (10%) H_2SO_4 imbibed

Table 9 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia catechu* (Lot no. 7) as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Concentrated (98%) H_2SO_4 for 1 min.	57	43	45	21	34
2.	Concentrated (98%) H_2SO_4 for 2 min.	70	30	54	23	23
3.	Concentrated (98%) H_2SO_4 for 3 min.	87	13	69	26	5
4.	Concentrated (98%) H_2SO_4 for 5 min.	99	1	73	27	--
5.	Concentrated (98%) H_2SO_4 for 10 min.	100	--	75	25	--
6.	Concentrated (98%) H_2SO_4 for 15 min.	100	--	72	28	--
7.	Concentrated (98%) H_2SO_4 for 30 min.	100	--	70	30	--
8.	Concentrated (98%) H_2SO_4 for 45 min.	100	--	59	41	--
9.	Diluted (50%) H_2SO_4 for 2 min.	52	48	33	22	45
10.	Diluted (50%) H_2SO_4 for 5 min.	59	41	41	24	35
11.	Diluted (50%) H_2SO_4 for 10 min.	71	29	53	25	22
12.	Diluted (50%) H_2SO_4 for 30 min.	86	14	69	27	4
13.	Diluted (50%) H_2SO_4 for 60 min.	98	2	71	28	1
14.	Diluted (50%) H_2SO_4 for 90 min.	100	--	58	42	--
15.	Diluted (10%) H_2SO_4 for 10 hrs.	65	35	45	23	32
16.	Diluted (10%) H_2SO_4 for 20 hrs.	80	20	52	29	19
17.	Diluted (10%) H_2SO_4 for 30 hrs	100	--	49	51	--
18.	Mechanical scarification (Filing)	100	--	83	17	--
19.	Mechanical scarification (Nicking)	100	--	79	21	--
20.	Control	16	84	31	20	49

100% seeds but germination was lowered as some seeds became dead (49 % germinated ; 51% dead). This may be due to the toxic effect of acid on the seeds as they were kept for a long time in it.

MECHANICAL SCARIFICATION :

Filing gave 100% imbibition of seeds after 20 hour soaking. Best germination percentage (83%) was found by this treatment and minimum number of seeds became dead (17% Vs 20% in control).

Acacia nilotica (Lot No. 8) :

HEAT TREATMENT :

Table 10 shows that soaking the seeds of ***A. nilotica*** in water at 40°C for 12 & 24 hours gave better imbibition (52 - 59% Vs 34% in control) but lesser germination (5 - 7% Vs 8% in control). Dry heat treatment (40° , 60° and 80° C) for 5, 10 and 15 days followed by 20 hours water soaking gave better imbibition than control (48% - 56% Vs 34% in control) but percent germination was moderate ranging between 8 - 13 % in various temperature and durations. Number of hard and dead seeds were found in range between 39 - 53%.

CHEMICAL TREATMENT :

Chemicals gave slightly better germination percentage (7-21% Vs 8% in control). $K_2Cr_2O_7$ was found to be the best among the chemicals (17 - 21%, germination Vs 8% in control). Number of dead seeds increased abruptly after the chemical pretreatments (68-87% Vs 27% in control) showing their injurious effect on the seeds. Only a few hard seeds were left after the experiment.

Table 10 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia nilotica* (Lot no. 8) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seed soaked in water (40°C) for 12 hrs	52	48	5	47	48
2.	Seed soaked in water (40°C) for 24 hrs	59	41	7	52	41
3.	Seeds kept in oven at 40°C for 5 days	48	52	8	40	52
4.	Seeds kept in oven at 40°C for 10 days	51	49	10	43	47
5.	Seeds kept in oven at 40°C for 15 days	54	46	13	44	43
6.	Seeds kept in oven at 60°C for 5 days	49	51	10	41	49
7.	Seeds kept in oven at 60°C for 10 days	54	46	12	47	41
8.	Seeds kept in oven at 60°C for 15 days	55	45	9	52	39
9.	Seeds kept in oven at 80°C for 5 days	51	49	11	49	40
10.	Seeds kept in oven at 80°C for 10 days	56	44	9	53	38
11.	Potessium nitrate (10%) for 10 hrs.	3	97	11	82	7
12.	Potessium nitrate (10%) for 20 hrs.	5	95	9	86	5
13.	Potessium dichromate (5%) for 10 hrs.	5	95	21	68	11
14.	Potessium dichromate (5%) for 20 hrs.	4	96	17	75	8
15.	Sodium Nitrite (5%) for 10 hrs.	21	79	13	80	7
16.	Sodium Nitrite (5%) for 20 hrs.	23	77	9	87	4
17.	Thiourea (5%) for 10 hrs.	11	89	10	71	19
18.	Thiourea (5%) for 20 hrs.	13	87	7	78	15
19.	Cattle urine (5%) for 10 hrs.	21	79	12	73	15
20.	Cattle urine (5%) for 20 hrs.	24	76	9	87	4
21.	Mechanical scarification (Filing)	100	--	33	67	--
22.	Control	34	66	8	27	65

MECHANICAL SCARIFICATION :

Filing found to be the best giving 33% germination. Rest of the seeds (67%) could be germinated and deteriorated ultimately showing the poor quality of the seed lot.

Acacia nilotica (Lot no. 9):

HEAT TREATMENT :

As indicated in Table 11 that soaking the seeds in water at 40°C for 12 and 24 hours and dry heat treatment (40°, 60° and 80°C) for 5, 10 and 15 days did not effect the permeability of seed coat. The imbibition was almost similar to that in control after 20 hour water soaking (37 - 51% Vs 42% in control). Fifty five percent germination was best among these pretreatments which was obtained by soaking in water of 40°C for 24 hours. Percent germination became down by other heat treatment (21-32% Vs 57% in control). Hard seeds remained at the end of the experiment were more than those in control (23 to 58% Vs 25% in control). Number of dead seeds also increased (21 - 52% Vs 18% in control) indicating that dry heat treatments were harmful for germination the seeds.

CHEMICAL TREATMENTS :

As shown in Table 11, chemicals like $K_2Cr_2O_7$ and thiourea gave (58 - 65%) better germination than control (57%). Dead seed percentage increased by other two chemicals (KNO_3 : 39 - 43% and $NaNO_2$: 35 - 37%), cattle urine

Table 11 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia nilotica* (Lot no.9) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seed soaked in water (40°C) for 12 hrs.	37	63	27	28	45
2.	Seed soaked in water (40°C) for 24 hrs.	43	57	55	30	15
3.	Seed kept in oven at (40°C) for 5 days	51	49	21	21	58
4.	Seed kept in oven at (40°C) for 10 days	42	58	28	27	45
5.	Seed kept in oven at (40°C) for 15 days	46	54	32	42	26
6.	Seed kept in oven at (60°C) for 5 days	35	65	27	39	34
7.	Seed kept in oven at (60°C) for 10 days	39	61	31	43	26
8.	Seed kept in oven at (60°C) for 15 days	41	59	30	47	23
9.	Seed kept in oven at (80°C) for 5 days	42	58	28	43	29
10.	Seed kept in oven at (80°C) for 10 days	47	53	21	52	27
11.	Potassium nitrate (10%) for 10 hrs.	13	87	8	39	53
12.	Potassium nitrate (10%) for 20 hrs.	12	88	5	43	52
13.	Potassium dichromate (5%) for 10 hrs.	15	85	59	15	26
14.	Potassium dichromate (5%) for 20 hrs.	13	87	65	16	19
15.	Sodium nitrite (5%) for 10 hrs.	25	75	35	37	28
16.	Sodium nitrite (5%) for 20 hrs.	27	73	37	40	23
17.	Thiourea (5%) for 10 hrs.	15	85	61	20	19
18.	Thiourea (5%) for 20 hrs.	17	83	58	25	17
19.	Cattle urine for 10 hrs.	11	89	45	27	28
20.	Cattle urine for 20 hrs.	13	87	48	29	23
21.	Mechanical scarification (Filing).	100	--	69	31	--
22.	Control	42	58	57	18	25

was found to be less destructive (27 - 29%). Many seeds did not imbibed and remained hard (52 - 53%) when treated with KNO_3.

MECHANICAL SCARIFICATION :

Filing gave 100% imbibition out of which 69% seeds germinated (57% in control) showing its superiority over other treatments.

Many seeds which remain hard and do not imbibe readily were found to be non - viable in this species.

Acacia nilotica (Lot - 9) :

ACID TREATMENT :

According to Table 12, sixty minute scarification with conc. (98%) H_2SO_4 followed by 20 hours soaking gave better germination (51% Vs 49% in control). Lesser germination was found in lesser duration as well as in higher duration of treatment (37 - 46% Vs 49% in control) 90 minute treatment showed maximum imbibition (94% Vs 59% in control) and maximum number of dead seeds (54% Vs 31% in control). Some hard seeds remained at the end of all treatment except 90 minute duration.

Duration of 90 minute soaking in 50% H_2SO_4 was found to be effective for imbibition (69% Vs 59% in control) but not for germination (46% Vs 49% in control).

Thirty - hour - soaking in diluted (10%) H_2SO_4 gave better germination (49% Vs 29% in control) leaving some hard seeds. When duration of soaking was increased, the imbibition increased but germination decreased

Table 12 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia nilotica* (Lot no.9) as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
23.	Concentrated (98%) H_2SO_4 for 1 min	45	55	37	25	38
24.	Concentrated (98%) H_2SO_4 for 2 min	49	51	38	30	32
25.	Concentrated (98%) H_2SO_4 for 3 min	51	49	41	30	29
26.	Concentrated (98%) H_2SO_4 for 5 min	52	48	43	29	28
27.	Concentrated (98%) H_2SO_4 for 10 min	53	47	40	33	27
28.	Concentrated (98%) H_2SO_4 for 15 min	55	45	40	34	26
29.	Concentrated (98%) H_2SO_4 for 30 min	59	41	42	39	19
30.	Concentrated (98%) H_2SO_4 for 45 min	65	35	45	39	16
31.	Concentrated (98%) H_2SO_4 for 60 min	79	21	51	38	11
32.	Concentrated (98%) H_2SO_4 for 90 min	94	6	46	54	--
33.	Diluted (50%) H_2SO_4 for 2 min.	37	63	13	25	62
34.	Diluted (50%) H_2SO_4 for 5 min	41	59	19	24	57
35.	Diluted (50%) H_2SO_4 for 10 min	48	52	23	26	51
36.	Diluted (50%) H_2SO_4 for 30 min	53	47	32	30	38
37.	Diluted (50%) H_2SO_4 for 60 min	61	39	40	29	31
38.	Diluted (50%) H_2SO_4 for 90 min	69	31	46	31	23
39.	Diluted (50%) H_2SO_4 for 180 min	65	35	38	40	22
40.	Diluted (10%) H_2SO_4 for 10 hrs.	47	53	35	42	23
41.	Diluted (10%) H_2SO_4 for 20 hrs.	61	39	49	36	15
42.	Diluted (10%) H_2SO_4 for 30 hrs.	73	27	29	59	12
43.	Mechanical scarification (Nicking)	100	--	53	47	--
44.	Mechanical scarification (Burning)	100	--	48	52	--
45.	Control	59	41	49	31	20

(Imbibition : 73%, germination : 29%). Due to lethal effect of the acid, more seeds became dead (59%) after 30 hours soaking.

MECHANICAL SCARIFICATION :

Mechanically scarified seeds showed 100% imbibition. Nicking gave the best germination (53% Vs 49% in control) but seeds burned with hot iron rod was harmful as some seeds became dead due to heat injury to the embryo (48% germination and 52% dead seeds Vs 53% germinated and 47% dead seeds in nicking).

Acacia nilotica (Lot no. 11):

CHEMICAL TREATMENT :

As shown in Table 13, chemical treatment was not found to be effective to improve permeability as well as percent germination (37% to 61% Vs 61% in control) of seeds of ***A. nilotica.*** More number of hard seeds remained after the experiment (32 - 58% Vs 32% in control) showed that different chemicals hardened the seeds especially cattle urine and thiourea.

HOT WATER TREATMENT :

Seeds soaked in hot water (60°C and 80°C) for different time periods gave good imbibition after 20 hr. water soaking (59 - 84% Vs 17% in control). Treatment of 60°C for 5 - 7 hrs. gave 79% and 71% germination (61% in control) Hot water found to be harmful for seeds as longer duration increased percentage of dead seeds (12 - 75% Vs 71% in control).

Table 13 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia nilotica* (Lot no.11) as affected by chemical and hot water pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Potassium nitrate (10%) for 10 hrs	7	93	60	5	35
2.	Potassium nitrate (10%) for 20 hrs.	9	91	61	7	32
3.	Potassium dichromate (5%) for 10 hrs.	8	92	47	5	48
4.	Potassium dichromate (5%) for 20 hrs.	11	89	50	4	46
5.	Thiourea (5%) for 10 hrs.	5	95	36	6	58
6.	Thiourea (5%) for 20 hrs.	6	94	37	8	55
7.	Sodium nitrite (5%) for 10 hrs.	6	94	46	9	45
8.	Sodium nitrite (5%) for 20 hrs.	8	92	45	12	43
9.	Cattle urine for 10 hrs.	10	90	35	10	55
10.	Cattle urine for 20 hrs.	12	88	37	11	52
11.	Hot water soaking (60°C) for 5 hrs.	65	35	79	12	9
12.	Hot water soaking (60°C) for 7 hrs.	68	32	71	24	5
13.	Hot water soaking (60°C) for 20 hrs.	78	22	29	69	2
14.	Hot water soaking (80°C) for 4 hrs.	59	41	52	47	1
15.	Hot water soaking (80°C) for 11 hrs.	78	22	29	71	--
16.	Hot water soaking (80°C) for 20 hrs.	84	16	25	75	--
17.	Mechanical scarification (Filing)	100	--	89	11	--
18.	Control	17	83	61	7	32

MECHANICAL SCARIFICATION :

Hundred percent imbibition was given by filing of seeds out of which most of the seeds germinated (89% Vs 61% in control). This treatment was found to be the best in *A. nilotica* .

A. nilotica (Lot no 11):

BOILING WATER TREATMENT :

As indicated in Table 14, boiling water gave good results in *A. nilotica.* Seeds droped in boiling water and allowed to cool gave 85% germination (59% in control). When the duration of treatment was increased, the percentage germination decreased while percentage of dead seeds increased showing the injurious effect of boiling water on the seed embryo. Number of hard seeds also decreased gradually with increase in the duration of treatment.

SHOCK TREATMENT :

Excellent results were obtained when 5 sec. boiling and 5 sec. ice water dip was experienced with seeds of this species. Increasing the duration and frequency of the treatment increased the percentage germination. Ten seconds for 1 time gave the best germination percentage (93% Vs 59% in control). A few hard seeds were also left after each treatment while some seeds became dead.

MECHANICAL SCARIFICATION :

Clipping gave 100% imbibition after 20 hr. soaking the seeds in water. No other treatment (boiling water and shock treatment) could imbibe all the

Table 14 : Percentage of imbibed, hard, germinated and dead seeds of *Acacia nilotica* (Lot no. 11)as affected by boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
19.	Boiling water dipping	26	74	85	3	12
20.	Boiling water soaking for 5 sec.	27	73	79	11	10
21.	Boiling water soaking for 10 sec.	30	70	72	19	9
22.	Boiling water soaking for 20 sec.	41	59	70	24	6
23.	Boiling water soaking for 30 sec.	49	51	63	30	7
24.	Boiling water soaking for 1 min.	53	47	20	72	8
25.	Boiling water soaking for 2 min.	57	43	13	85	2
26.	Boiling water soaking for 5 min.	63	37	8	91	1
27.	Boiling water/ice water 5 sec.-1 time	33	67	83	4	13
28.	Boiling water/ice water 5 sec.-2 times	39	61	88	3	9
29.	Boiling water/ice water 5 sec.-5 times	48	52	90	7	3
30.	Boiling water/ice water 10 sec.-1 time	40	60	93	2	5
31.	Boiling water/ice water 10 sec.-2 times	45	55	91	6	3
32.	Boiling water/ice water 10 sec.-5 times	49	51	89	9	2
33.	Mechanical scarification (Clipping)	100	--	90	10	--
34.	Control	15	85	59	6	35

seeds of this species. Percentage germination was fairly good (90%) and some dead seeds (10%) were also observed.

Albizia lebbek (Lot no. 16) :

As shown in Table 15, seeds of ***A. lebbek*** being very old, did not responded to dry heat and chemical treatment, control and soaking in water (40°C) was the highest while cattle urine germinated a few seeds . Rest of the treatment either kept the seeds hard or many of them were deteriorated. After every treatments some seeds remained hard except mechanical scarification. It seems that seeds have lost their viability during a long term storage. Such seeds when kept at dry heat, they became more hard but not germinable.

Albizia lebbek (Lot no. 17) :

ACID TREATMENT :

As shown in Table 16, forty five minute treatment gave very good germination (61% Vs 32 % in control) by soaking of seeds in conc. (98%) H_2SO_4 followed by 20 hours water soaking. All the seeds imbibed when treated for 45 - 90 min. duration leaving no hard seed. Injurious effect of acid was shown when the duration of treatment was increased up to 60 or 90 minute (41% to 58% Vs 35 % in control).

Diluted (50%) H_2SO_4 also gave better germination (33 to 40 % Vs 32 % in control). Scarification for 90 min. gave 92% imbibition and better

Table 15 : Percentage of imbibed, hard, germinated and dead seeds of *Albizia lebbek* (Lot no. 16) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	91	9	12	84	4
2.	Seeds soaked in water (40°C) for 24 hrs.	96	4	3	93	4
3.	Seeds kept in oven at 40°C for 5 days	55	45	2	22	76
4.	Seeds kept in oven at 40°C for 10 days	41	59	--	34	66
5.	Seeds kept in oven at 40°C for 15 days	23	77	--	52	48
6.	Seeds kept in oven at 60°C for 5 days	23	77	--	27	73
7.	Seeds kept in oven at 60°C for 10 days	24	76	--	35	65
8.	Seeds kept in oven at 60°C for 15 days	25	75	--	69	31
9.	Seeds kept in oven at 80°C for 5 days	13	87	--	63	37
10.	Seeds kept in oven at 80°C for 10 days	22	78	--	84	16
11.	Potassium nitrate (10%) for 10 hrs.	72	28	--	87	13
12.	Potassium nitrate (10%) for 20 hrs.	80	20	--	96	4
13.	Potassium dichromate (5%) for 10 hrs.	49	51	--	59	41
14.	Potassium dichromate (5%) for 20 hrs.	57	43	--	64	36
15.	Sodium nitrite (5%) for 10 hrs.	71	29	--	78	22
16.	Sodium nitrite (5%) for 20 hrs.	75	25	--	84	16
17.	Thiourea (5%) for 10 hrs.	77	23	--	89	11
18.	Thiourea (5%) for 20 hrs.	82	18	--	96	4
19.	Cattle urine (5%) for 10 hrs.	87	13	2	89	9
20.	Cattle urine (5%) for 20 hrs.	91	9	5	91	4
21.	Mechanical Scarification (Filing)	100	--	8	92	--
22.	Control	59	41	12	52	36

germination (42%) but acid became harmful when the duration was increased (60% Vs 35% in control). Some seeds remained hard when duration was less than 90 minute (7% in 60 minute).

When the seeds were soaked in diluted (10%) H_2SO_4 , germination was increased (35% to 48% Vs 32 % in control) as the duration of treatment was increased. Maximum imbibition was shown in 30 hours duration(98% Vs 67% in control) leaving no hard seed at the end. Number of dead seeds increased with the increase in duration of treatment (38 - 52% Vs 35% in control).

MECHANICAL SCARIFICATION :

100% imbibition was noticed by filing the seeds followed by 20 hour water soaking. Best germination percentage (65% Vs 32% in control) was obtained by this treatment.

A. lebbek (Lot no. 18) :

HOT WATER TREATMENT :

Table 17 indicated that 20 hour soaking at 60°C gave very good germination percentage (73%) leaving no hard seed. Other temperature and durations (80°C for 4, 11 and 20 hrs) deteriorated most of the seeds resulting in low percentage germination.

BOILING WATER TREATMENT :

Percentage germination of seed was increased when the duration of treatment was increased and at 5 min duration it reached upto 79%. Number of hard seeds gradually decreased with increase in the duration of treatment.

Table 16 : Percentage of imbibed, hard, germinated and dead seeds of *Albizia lebbek* (Lot no. 17) as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Concentrated (98%) H_2SO_4 for 1 min.	69	31	32	38	30
2.	Concentrated (98%) H_2SO_4 for 2 min.	70	30	34	39	27
3.	Concentrated (98%) H_2SO_4 for 3 min.	73	27	35	40	25
4.	Concentrated (98%) H_2SO_4 for 5 min.	76	24	37	40	23
5.	Concentrated (98%) H_2SO_4 for 10 min.	87	13	50	36	14
6.	Concentrated (98%) H_2SO_4 for 15 min.	91	9	54	40	6
7.	Concentrated (98%) H_2SO_4 for 30 min.	96	4	57	40	3
8.	Concentrated (98%) H_2SO_4 for 45 min.	100	--	61	39	--
9.	Concentrated (98%) H_2SO_4 for 60 min.	100	--	59	41	--
10.	Concentrated (98%) H_2SO_4 for 90 min.	100	--	42	58	--
11.	Diluted (50%) H_2SO_4 for 2 min.	68	32	33	36	31
12.	Diluted (50%) H_2SO_4 for 5 min.	69	31	33	38	29
13.	Diluted (50%) H_2SO_4 for 10 min.	71	29	34	42	24
14.	Diluted (50%) H_2SO_4 for 30 min.	76	24	36	49	15
15.	Diluted (50%) H_2SO_4 for 60 min.	87	13	39	54	7
16.	Diluted (50%) H_2SO_4 for 90 min.	92	8	42	58	--
17.	Diluted (50%) H_2SO_4 for 180 min.	100	--	40	60	--
18.	Diluted (10%) H_2SO_4 for 10 hrs.	71	29	35	38	27
19.	Diluted (10%) H_2SO_4 for 20 hrs.	85	15	45	41	14
20.	Diluted (10%) H_2SO_4 for 30 hrs.	98	2	48	52	--
21.	Mechanical scarification (Filing)	100	--	65	35	--
22.	Control	40	60	32	35	33

SHOCK TREATMENT :

Different times and durations of boiling and ice water dipping gave 50% to 66% germination which was increased accordingly as the times and duration was increased. A few seeds remained hard but many seeds were deteriorated (34 to 40 % Vs 12% in control).

MECHANICAL SCARIFICATION :

Hundred percent imbibition was noticed when seeds were clipped (scarified). Highest germination percentage (92%) was recorded by this treatment.

Due to insect attack in glass bottles at room temperature, seeds were kept in the oven spreading in the tray at 60°C. After two days seeds remained at room temperature for four days as the switch of the oven was off. After 4 days the switch of the oven was on for another 2 days and again the gap of 4 days. In this way the seeds were kept at alternating temperature (Dry heat) for one month. The period of oven on/off is given approximately. This was done to get rid of the insect infestation. Thus shock and boiling water treatments were done with such seeds. Control reflects the pre - treated nature of seeds as it gave fairly higher (80%) germination.

Table 17 : Percentage of imbibed, hard, germinated and dead seeds of *Albizia lebbek* (Lot no. 18) as affected by hot water, boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Hot water soaking (60°C) for 5 hrs.	39	61	45	35	20
2.	Hot water soaking (60°C) for 7 hrs.	60	40	44	40	16
3.	Hot water soaking (60°C) for 20 hrs.	82	18	73	27	--
4.	Hot water soaking (80°C) for 4 hrs.	59	41	37	60	3
5.	Hot water soaking (80°C) for 11 hrs.	92	8	21	79	--
6.	Hot water soaking (80°C) for 20 hrs.	96	4	17	83	--
7.	Boiling water dipping	13	87	58	35	7
8.	Boiling water soaking for 5 sec.	17	83	59	35	6
9.	Boiling water soaking for 10 sec.	20	80	56	39	5
10.	Boiling water soaking for 20 sec.	22	78	61	36	3
11.	Boiling water soaking for 30 sec.	23	77	68	30	2
12.	Boiling water soaking for 1 min.	25	75	70	28	2
13.	Boiling water soaking for 2 min.	27	73	74	25	1
14.	Boiling water soaking for 5 min.	30	70	79	21	--
15.	Boiling water/ice water 5 sec. - 1 time	12	88	50	40	10
16.	Boiling water/ice water 5 sec. - 2 times	15	85	53	42	5
17.	Boiling water/ice water 5 sec. - 5 times	19	81	57	42	1
18.	Boiling water/ice water 10 sec. - 1 time	20	80	59	38	3
19.	Boiling water/ice water 10 sec. - 2 times	22	78	61	39	--
20.	Boiling water/ice water 10 sec. - 5 times	25	75	66	34	--
21.	Mechanical scarification (Clipping)	100	--	92	8	--
22.	Control	11	89	80	12	8

Due to insect attack seeds were kept in oven (60°C) at alternating temperature (i.e. - 2 days - 60°C ; 4 days 35°C) for one month. All the treatments were conducted on such seeds.

Cassia fistula (Lot no. 23) :

HEAT TREATMENT :

As shown in Table 18, hot water at 40°C for 12 and 24 hours and dry heat (40°C, 60°C & 80°C) for 5,10 and 15 days did not improve imbibition. Water soaking after the dry heat treatment, resulted poor imbibition (3 - 12 % Vs 8% in control) resulting low germination percentage of seeds (1 to 5% Vs 5% in control). Heating at 80°C gave better results in imbibition (21 to 35%). Number of dead seeds increased (2 to 31% Vs 4% in control) showing that higher temperature for a long time was injurious to the seeds.

CHEMICAL TREATMENT :

Chemicals did not show any change in the germination percentage (2 - 5% Vs 5% in control). Number of dead (2 - 8% Vs 4 % in control) and hard seeds were also found to be similar to that of control.

HOT WATER TREATMENT :

Hot water gave better imbibition (15 to 71%) than control (8%) after 5 to 20 hour water soaking. Hot water treatment of 60°C for 20 hours gave best result (80% germination) however, other duration also improved germination over control (64 to 75% Vs 5%). Higher temperature (80°C) soaking was found to be harmful in this species as the number of dead seeds were increased (45 - 48%).

MECHANICAL SCARIFICATION :

Hundred percent imbibition was obtained by mechanical scarification. Filing found to be the best (89%). Nicking gave better germination (85%) than

Table 18 : Percentage of imbibed, hard, germinated and dead seeds of *Cassia fistula* (Lot no. 23) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	3	97	1	2	97
2.	Seed soaked in water (40°C) for 24 hrs.	12	88	5	11	84
3.	Seeds kept in oven at 40°C for 5 days	2	98	1	2	97
4.	Seeds kept in oven at 40°C for 10 days	2	98	1	2	97
5.	Seeds kept in oven at 40°C for 15 days	3	97	1	3	96
6.	Seeds kept in oven at 60°C for 5 days	7	93	1	7	92
7.	Seeds kept in oven at 60°C for 10 days	11	89	3	8	89
8.	Seeds kept in oven at 60°C for 15 days	5	95	1	11	88
9.	Seeds kept in oven at 80°C for 5 days	21	79	4	22	74
10.	Seeds kept in oven at 80°C for 10 days	35	65	5	31	64
11.	Potassium nitrate (10%) for 10 hrs.	2	98	--	2	98
12.	Potassium nitrate (10%) for 20 hrs.	4	96	2	3	95
13.	Potassium dichromate (5%) for 10 hrs.	3	97	1	2	97
14.	Potassium dichromate (5%) for 20 hrs.	8	92	5	4	91
15.	Sodium nitrite (5%) for 10 hrs.	4	96	1	3	96
16.	Sodium nitrite (5%) for 20 hrs.	9	91	3	8	89
17.	Thiourea (5%) for 10 hrs.	5	95	2	3	95
18.	Thiourea (5%) for 20 hrs.	7	93	5	4	91
19.	Cattle urine for 10 hrs.	5	95	3	3	94
20.	Cattle urine for 20 hrs.	9	91	5	6	89

Table : 18 (Continued) Percentage of imbibed, hard, germinated and dead seeds of *Cassia fistula* (Lot no. 23) as affected by hot water and mechanical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
21.	Hot water soaking (60°C) for 5 hrs.	15	85	64	16	20
22.	Hot water soaking (60°C) for 7 hrs.	23	77	75	18	7
23.	Hot water soaking (60°C) for 20 hrs.	32	68	80	20	--
24.	Hot water soaking (80°C) for 4 hrs.	63	37	45	47	8
25.	Hot water soaking (80°C) for 11 hrs.	67	33	52	48	--
26.	Hot water soaking (80°C) for 20 hrs.	71	29	55	45	--
27.	Mechanical scarification (Filing)	100	--	89	11	--
28.	Mechanical scarification (Nicking)	100	--	85	15	--
29.	Mechanical scarification (Burning)	100	--	80	20	--
30	Control	8	92	5	4	91

burning (81%). Due to injury burning gave more dead seeds than filing or nicking (19% Vs 1 or 15%).

Cassia fistula (Lot No. 24) :

ACID TREATMENT :

As indicated inTable 19, maximum imbibition (100% Vs 1% in control) was found after 20 hours water soaking of seeds pretreated by conc. (98 %) H_2SO_4 for 90 min. duration. It gave very good germination (85% Vs 1% in control) leaving no hard seed at the end. As the time period increased (1 - 90 min), number of imbibed seeds (1 - 100%), percentage germination (1 - 85%) and number of dead seeds increased (1 - 15%), but number of hard seeds decreased (99 - 0%).

Similar trend was noticed when seeds were soaked in 50% H_2SO_4. As the duration of treatment increased, percent germination increased with reduction in hard seeds. This trend was observed upto 180 minute duration by which 30% germination was noticed leaving 65% hard seeds.

Diluted (10%) H_2SO_4 was not found to be effective for softening the seed coat. Germination was slightly better (2 - 8%) than control. A few seeds became dead (1 - 7% Vs 1% in control) leaving good number of hard seeds.

MECHANICAL SCARIFICATION : Filing and nicking gave 100% imbibition after soaking the seeds in water for 20 hour duration. Highest (90%) germination was obtained by filing and 86% by nicking indicated that this method showing its superiority over other pretreatments.

Table 19 : Percentage of imbibed, hard, germinated and dead seeds of *Cassia fistula* (Lot no. 24) as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Concentrated (98%) H_2SO_4 for 1 min.	1	99	--	1	99
2.	Concentrated (98%) H_2SO_4 for 2 min.	1	99	1	--	99
3.	Concentrated (98%) H_2SO_4 for 3 min.	2	98	1	1	98
4.	Concentrated (98%) H_2SO_4 for 5 min.	3	97	1	2	97
5.	Concentrated (98%) H_2SO_4 for 10 min.	7	93	4	3	93
6.	Concentrated (98%) H_2SO_4 for 15 min.	9	91	6	3	91
7.	Concentrated (98%) H_2SO_4 for 30 min.	21	79	18	3	79
8.	Concentrated (98%) H_2SO_4 for 45 min.	84	16	76	9	15
9.	Concentrated (98%) H_2SO_4 for 60 min.	90	10	80	11	9
10.	Concentrated (98%) H_2SO_4 for 90 min.	100	--	85	15	--
11.	Diluted (50%) H_2SO_4 for 2 min.	1	99	1	--	99
12.	Diluted (50%) H_2SO_4 for 5 min.	2	98	1	1	98
13.	Diluted (50%) H_2SO_4 for 10 min.	3	97	2	1	97
14.	Diluted (50%) H_2SO_4 for 30 min.	7	93	4	3	93
15.	Diluted (50%) H_2SO_4 for 60 min.	10	90	8	3	89
16.	Diluted (50%) H_2SO_4 for 90 min.	18	82	15	4	81
17.	Diluted (50%) H_2SO_4 for 180 min.	31	69	30	5	65
18.	Diluted (10%) H_2SO_4 for 10 hrs.	3	97	2	1	97
19.	Diluted (10%) H_2SO_4 for 20 hrs.	7	93	4	3	93
20.	Diluted (10%) H_2SO_4 for 30 hrs.	15	85	8	7	85
21.	Mechanical scarification (Filing)	100	--	90	10	--
22.	Mechanical scarification (Nicking)	100	--	86	14	--
23.	Control	1	99	1	1	98

C. fistula (Lot no. 25) :

HOT WATER TREATMENT :

As shown in Table 20, better results were obtained when seeds were soaked in water at 60°C for 5, 7 and 20 hours (49%, 53% and 60% germination Vs 6% in control). Soaking at 80°C also gave better germination percentage than that of control. No hard seed was left at 80°C temperature for all duration and at 60°C for 20 hr duration indicating the sensitivity of seed embryo to the heat in prolonged soaking in hot water.

BOILING WATER TREATMENT :

Boiling water for a little time could not make the seed coat permeable to water as most of the seeds remained hard when kept in it upto 1 minute. Two and 5 minute duration of boiling water increased percentage germination (26 to 33 % germination) and also the number of dead seeds (53 to 64% dead seeds). Thus, it seems that higher temperature for longer duration killed the seed embryo making them non - viable.

SHOCK TREATMENT :

This treatment virtually showed no effect on seed dormancy and most of the seeds did not imbibe and remained hard upto the end of the experiment. Ten second boiling and 10 sec. ice water dipping gave 14% germination which was better than control but still not appreciable.

MECHANICAL SCARIFICATION :

Clipping the individual seed reflected its superiority over other treatments as 100% imbibition and best germination percentage (87% Vs 6%

Table 20 : Percentage of imbibed, hard, germinated and dead seeds of *Cassia fistula* (Lot no. 25) as affected by hot water, boiling water, and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Hot water soaking (60°C) for 5 hrs.	15	85	49	12	39
2.	Hot water soaking (60°C) for 7 hrs.	29	71	53	25	22
3.	Hot water soaking (60°C) for 20 hrs.	58	42	60	40	--
4.	Hot water soaking (80°C) for 4 hrs.	75	25	37	63	--
5.	Hot water soaking (80°C) for 11 hrs.	87	13	39	61	--
6.	Hot water soaking (80°C) for 20 hrs.	76	24	41	59	--
7.	Boiling water dipping	11	89	20	8	72
8.	Boiling water soaking for 5 sec.	2	98	5	7	88
9.	Boiling water soaking for 10 sec.	3	97	6	8	86
10.	Boiling water soaking for 20 sec.	5	95	9	10	81
11.	Boiling water soaking for 30 sec.	6	94	10	11	79
12.	Boiling water soaking for 1 min.	12	88	19	19	62
13.	Boiling water soaking for 2 min.	25	75	26	53	21
14.	Boiling water soaking for 5 min.	58	42	33	64	3
15.	Boiling water/ ice water 5 sec. 1 time	2	98	1	1	98
16.	Boiling water/ ice water 5 sec. 2 times	3	97	5	3	92
17.	Boiling water/ ice water 5 sec. 5 times	5	95	8	10	82
18.	Boiling water/ ice water 10 sec. 1 time	2	98	2	2	96
19.	Boiling water/ ice water 10 sec. 2 times	3	97	7	6	87
20.	Boiling water/ ice water 10 sec. 5 times	7	93	14	7	79
21.	Mechanical scarification (Clipping)	100	--	87	13	--
22.	Control	5	95	6	5	89

in control) was obtained. Thirteen percent seeds were found to be non - germinable and became dead at the end of the experiment.

Cassia siamea :

HEAT TREATMENT :

As shown in Table 21, seeds soaking in water of 40°C for 12 & 24 hrs. gave better imbibition than control. Dry heat treatment (40°, 60° and 80°C) for 5, 10 and 15 days improved permeability of seeds up to a little extent(22 to 39% Vs 19% in control) after 20 hour water soaking. Percent germination was found to be lower than that of control(3 to 13% Vs 13% in control). Percentage of dead seed was almost similar to that of control (45 - 59 % Vs 52% in control) leaving some hard seeds. It seems that heat injured some seeds so that they lost their viability.

CHEMICAL TREATMENT :

Chemicals used for pretreatment were found to be harmful for seed germination (3 to 8% Vs 13% in control). Chemicals slightly damaged the seeds due to which more seeds became dead (63 - 69 % Vs 52% in control) at the end of experiment.

MECHANICAL SCARIFICATION :

Filing exhibited 100% imbibition after 20 hrs soaking and gave better results in percent germination (35% Vs 13% in control) but percentage of dead seeds also increased (65% Vs 52% in control) leaving no hard seed.

Table 21 : Percentage of imbibed, hard, germinated and dead seeds of *Cassia siamea* as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	35	65	17	45	38
2.	Seeds soaked in water (40°C) for 24 hrs.	39	61	9	59	32
3.	Seeds kept in oven at 40°C for 5 days	22	78	13	49	38
4.	Seeds kept in oven at 40°C for 10 days	25	75	10	50	40
5.	Seeds kept in oven at 40°C for 15 days	30	70	9	52	39
6.	Seeds kept in oven at 60°C for 5 days	23	77	8	51	41
7.	Seeds kept in oven at 60°C for 10 days	27	73	6	53	41
8.	Seeds kept in oven at 60°C for 15 days	32	68	5	56	39
9.	Seeds kept in oven at 80°C for 5 days	25	75	7	55	38
10.	Seeds kept in oven at 80°C for 10 days	33	67	5	59	36
11.	Potassium nitrate (10%) for 10 hrs.	27	73	5	65	30
12.	Potassium nitrate (10%) for 20 hrs.	31	69	3	69	28
13.	Potassium dichromate (5%) for 10 hrs.	25	75	7	63	30
14.	Potassium dichromate (5%) for 20 hrs.	30	70	5	68	27
15.	Sodium nitrite (5%) for 10 hrs.	28	72	4	65	31
16.	Sodium nitrite (5%) for 20 hrs.	31	69	3	68	29
17.	Thiourea (5%) for 10 hrs.	26	79	5	64	31
18.	Thiourea (5%) for 20 hrs.	29	71	8	67	25
19.	Cattle urine for 10 hrs.	28	72	6	63	31
20.	Cattle urine for 20 hrs.	32	68	5	68	27
21.	Mechanical scarification (Filing)	100	--	35	65	--
22.	Control	19	81	13	52	35

ACID TREATMENT :

According to Table 22, conc. H_2SO_4 was found to improve the premeability of seed coat as 100% imbibition was given by 60 min treatment (29% in control) while 30 to 43 min treatment gave good germination percentage (29 - 30% Vs 9% in control). Number of dead seeds increased as the duration increased above 30 min. (71 - 79% Vs 59% in control) leaving no hard seed.

Diluted (50%) H_2SO_4 gave slightly better germination (13 - 19% Vs 9% in control) but the number of dead seeds increased when duration was above one hour (i.e. 90 and 180 min).

Ten hour duration of dilute (10%) H_2SO_4 was found better for germination (18%). Number of dead seeds was more than control when duration of treatment was increased above 10 hrs. (74 - 79 % Vs 59% in control).

MECHANICAL SCARIFICATION :

Filing gave 100% imbibition (29 % in control) and best germination percentage (43% Vs 9% in control) leaving no hard seed. Burning the seeds with hot iron badly injured the seed so that large no. of seeds became dead (83% Vs 59% in control).

HOT WATER TREATMENT :

Imbibition was 79 to 100% when seeds were kept in hot water for different durations (Table 23). Most of the imbibed seeds became dead leaving no hard seeds at 80°C for 11 to 20 hrs. Percent germination was better in 60°C soaking for 5 hour duration (20% Vs 7% in control). Some hard seeds were also left at 60°C temperature for various durations.

Table 22 : Percentage of imbibed, hard, germinated and dead seeds of *Cassia siamea* as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
23.	Concentrated (98%) H_2SO_4 for 1 min.	41	59	10	63	27
24.	Concentrated (98%) H_2SO_4 for 2 min.	51	49	13	62	25
25.	Concentrated (98%) H_2SO_4 for 3 min.	54	46	15	63	22
26.	Concentrated (98%) H_2SO_4 for 5 min.	59	41	16	64	20
27.	Concentrated (98%) H_2SO_4 for 10 min.	65	35	20	63	17
28.	Concentrated (98%) H_2SO_4 for 15 min.	71	29	23	63	14
29.	Concentrated (98%) H_2SO_4 for 30 min.	91	9	30	67	3
30.	Concentrated (98%) H_2SO_4 for 45 min.	95	5	29	71	--
31.	Concentrated (98%) H_2SO_4 for 60 min.	100	--	21	79	--
32.	Diluted (50%) H_2SO_4 for 2 min.	35	65	13	60	27
33.	Diluted (50%) H_2SO_4 for 5 min.	38	62	14	61	25
34.	Diluted (50%) H_2SO_4 for 10 min.	41	59	15	61	24
35.	Diluted (50%) H_2SO_4 for 30 min.	49	51	18	59	23
36.	Diluted (50%) H_2SO_4 for 60 min.	61	39	19	65	16
37.	Diluted (50%) H_2SO_4 for 90 min.	73	27	17	68	15
38.	Diluted (50%) H_2SO_4 for 180 min.	76	24	15	71	14
39.	Diluted (10%) H_2SO_4 for 10 hrs.	71	29	18	63	19
40.	Diluted (10%) H_2SO_4 for 20 hrs.	75	25	10	74	16
41.	Diluted (10%) H_2SO_4 for 30 hrs.	69	31	6	79	15
42.	Mechanical scarification (Nicking)	100	--	33	67	--
43.	Mechanical scarification (Burning)	100	--	27	73	--
44.	Control	29	71	9	59	32

Table 23 : Percentage of imbibed, hard, germinated and dead seeds of *Cassia siamea* as affected by hot water, boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
45.	Hot water soaking (60°C) for 5 hrs.	79	21	20	68	12
46.	Hot water soaking (60°C) for 7 hrs.	80	20	7	82	11
47.	Hot water soaking (60°C) for 20 hrs.	91	9	4	90	6
48.	Hot water soaking (80°C) for 4 hrs.	93	7	3	95	2
49.	Hot water soaking (80°C) for 11 hrs.	98	2	--	100	--
50.	Hot water soaking (80°C) for 20 hrs.	100	--	--	100	--
51.	Boiling water dipping	80	20	17	73	10
52.	Boiling water soaking for 5 sec.	80	20	15	75	10
53.	Boiling water soaking for 10 sec.	82	18	14	77	9
54.	Boiling water soaking for 20 sec.	89	11	12	82	6
55.	Boiling water soaking for 30 sec.	90	10	9	91	--
56.	Boiling water soaking for 1 min.	97	3	3	97	--
57.	Boiling water soaking for 2 min.	100	--	--	100	--
58.	Boiling water / ice water 5 sec. 1 time	39	61	16	76	8
59.	Boiling water / ice water 5 sec. 2 times	48	52	15	79	6
60.	Boiling water / ice water 5 sec. 5 times	60	40	12	84	4
61.	Boiling water / ice water 10 sec. 1 time	80	20	14	80	6
62.	Boiling water / ice water 10 sec. 2 times	86	14	13	84	3
63.	Boiling water / ice water 10 sec. 5 times	90	10	10	89	1
64.	Mechanical scarification (Clipping)	100	--	28	72	--
65.	Control	30	70	7	62	31

BOILING WATER TREATMENT :

Most of the treatment exhibited better germination when soaking in boiling water for different durations. Seeds dropped in boiling water gave maximum (17%) germination. When period of treatment was increased the percent germination decreased and after two minute duration all the seeds became dead. Thus longer duration of boiling water is fatal to seeds.

SHOCK TREATMENT :

Boiling and ice water dip for 5 seconds gave maximum (16%) germination after that increasing frequency and time gave lower germination percentage. Lower frequency and time left more hard seeds than at higher stage.

MECHANICAL SCARIFICATION :

Clipping gave 100% imbibition and the best percentage germination (28%) in this species. Rest of the seeds became dead showing that the seed was of poor quality.

Delonix regia (Lot no. 28) :

HEAT TREATMENT :

According to Table 24, seeds soaking in water at 40°C for 12 and 24 hours and dry heat conditions (40°, 60° and 80°C) for 5, 10 and 15 days followed by 20 hrs. water soaking softened some seeds giving better imbibition (8 - 15 % Vs 9% in control). Germination percentage was similar to that of control (5 - 10 % Vs 8% in control). Many seeds unaffected and remained hard showing that heat treatment had no effect on the seeds of ***D. regia.***

Table 24 : Percentage of imbibed, hard, germinated and dead seeds of *Delonix regia* (Lot no. 28) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	8	92	5	5	90
2.	Seeds soaked in water (40°C) for 24 hrs.	12	88	8	9	83
3.	Seeds kept in oven at (40°C) for 5 days	9	91	7	8	85
4.	Seeds kept in oven at (40°C)for 10 days	10	90	8	7	85
5.	Seeds kept in oven at (40°C) for 15 days	11	89	10	9	81
6.	Seeds kept in oven at (60°C) for 5 days	10	90	9	8	83
7.	Seeds kept in oven at (60°C) for 10 days	12	88	10	11	79
8.	Seeds kept in oven at (60°C) for 15 days	15	85	8	12	80
9.	Seeds kept in oven at (80°C) for 5 days	11	89	9	12	79
10.	Seeds kept in oven at (80°C) for 10 days	14	86	10	13	77
11.	Potassium nitrate (10%) for 10 hrs.	10	90	5	10	85
12.	Potassium nitrate (10%) for 20 hrs.	11	89	7	11	82
13.	Potassium dichromate (5%) for 10 hrs.	8	92	6	9	85
14.	Potassium dichromate (5%) for 20 hrs.	9	91	7	11	82
15.	Sodium nitrite (5%) for 10 hrs.	10	90	8	13	79
16.	Sodium nitrite (5%) for 20 hrs.	11	89	11	19	70
17.	Thiourea (5%) for 10 hrs.	7	93	6	8	86
18.	Thiourea (5%) for 20 hrs.	9	91	8	11	81
19.	Cattle urine for 10 hrs.	8	92	3	10	87
20.	Cattle urine for 20 hrs.	10	90	5	12	83
21.	Mechanical scarification (Filing)	100	--	85	15	--
22.	Control	9	91	8	7	85

CHEMICAL TREATMENT :

No chemical was found to be effective to improve germination percentage (3 to 11% Vs 8% in control). Number of dead seeds increased a little bit (9 to 19% Vs 7% in control) showing the lethal effect of chemicals. It seems that chemicals improved the permeability of hard seed coat of this species but could not improve the germination.

MECHANICAL SCARIFICATION :

Filing gave 100% imbibition after 20 hour soaking the seeds. Best germination (85%) was found and rest (15%) seeds became dead.

ACID TREATMENT :

As revealed by the Table 25, seed coat of ***D. regia*** seems to be very hard as after 3 hour soaking could imbibe only 50% of seeds giving 40% germination. Lesser duration did not affected the hard seed coat so that most of the seed remained hard. Four and five hours soaking in 98% H_2SO_4 resulted in 72% and 80% germination, respectively which was fairly good when compared to control(13%). After 6 and 7 hour soaking in acid, number of dead seed increased and percentage germination decreased (6 hrs - 21% ; 7 hrs - 8% germination). No hard seed was left in 5 to 7 hour treatment.

CONCENTRATED HCl AND HNO_3 :

Treatment of seeds with these acid did not show outstanding performance. Percentage germination was almost similar to that of control. HCl was little better than HNO_3 after 180 minute soaking. Most of the seeds remained hard at the end of the experiment.

Table 25 : Percentage of imbibed, hard, germinated and dead seeds of *Delonix regia* (Lot no. 28) as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
23.	Concentrated (98%) H_2SO_4 for 5 min.	11	89	13	5	82
24.	Concentrated (98%) H_2SO_4 for 10 min.	12	88	15	8	77
25.	Concentrated (98%) H_2SO_4 for 30 min.	15	85	18	10	72
26.	Concentrated (98%) H_2SO_4 for 45 min.	16	84	25	7	68
27.	Concentrated (98%) H_2SO_4 for 60 min.	17	83	29	4	67
28.	Concentrated (98%) H_2SO_4 for 90 min.	19	81	35	8	57
29.	Concentrated (98%) H_2SO_4 for 3 hrs.	31	69	40	15	45
30.	Concentrated (98%) H_2SO_4 for 4 hrs.	75	25	72	23	5
31.	Concentrated (98%) H_2SO_4 for 5 hrs.	90	10	80	20	--
32.	Concentrated (98%) H_2SO_4 for 6 hrs.	100	--	21	79	--
33.	Concentrated (98%) H_2SO_4 for 7 hrs.	100	--	8	92	--
34.	Concentrated HCl for 60 min.	9	91	12	3	85
35.	Concentrated HCl for 120 min.	11	89	15	5	80
36.	Concentrated HCl for 180 min.	15	85	20	8	72
37.	Concentrated HNO_3 for 60 min.	7	93	12	5	83
38.	Concentrated HNO_3 for 120 min.	8	92	14	6	80
39.	Concentrated HNO_3 for 180 min.	13	87	17	9	74
40.	Diluted (50%) H_2SO_4 for 60 min.	7	93	7	5	88
41.	Diluted (50%) H_2SO_4 for 90 min.	9	91	10	5	85
42.	Diluted (50%) H_2SO_4 for 180 min.	13	87	7	11	82
43.	Diluted (10%) H_2SO_4 for 10 hrs.	7	93	5	7	88
44.	Diluted (10%) H_2SO_4 for 20 hrs.	8	92	8	2	90
45.	Diluted (10%) H_2SO_4 for 30 hrs.	13	87	12	8	80
46.	Mechanical scarification (Burning)	100	--	72	28	--
47.	Mechanical scarification (Nicking)	100	--	81	19	--
48.	Control	12	88	13	8	79

DILUTED (50% AND 10%) H_2SO_4 :

Fifty percent sulphuric acid for 60, 90 and 180 minute and 10% for 10, 20 and 30 hour soaking could not remove the coat imposed dormancy of *D. regia* seeds. Most of the seeds remained hard and germination was below control (5 to 12 % Vs 13 % in control).

MECHANICAL SCARIFICATION :

Burning the seed coat with the help of shouldering iron rod imbibed all the seed giving 100% imbibition. Germination percentage was quite good (72% Vs 13% in control) leaving no hard seed. Nicking also gave 100% imbibition but percentage germination was highest (81%) among all the treatments. It seems that due to embryo damage during burning, more seeds became dead resulting lower germination percentage.

HOT WATER TREATMENT :

Table 26 indicated that hot water at 60°C had no effect upto 7 hours, resulting low germination of seeds. Four hours at 80°C improved germination upto 17% (15% in control) but 11 hour duration showed decrease in it. Twenty hour soaking at 60°C showed nil germination and seeds either became dead or remained hard. Eighty degree soaking for 20 hrs. deteriorated 96% seeds indicating the sensitivity of heat at prolong exposure.

BOILING WATER TREATMENT :

When seeds were kept in boiling water, their hard seed coat got permeable resulting higher imbibition of seeds. Twenty seconds to 2 minute duration showed increasing percentage germination which was fairly good (32 % to 42% Vs 15 % in control). Five minute in boiling water killed 70% seeds

Table 26 : Percentage of imbibed, hard, germinated and dead seeds of *Delonix regia* (Lot no. 28) as affected by hot water, boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
49.	Hot water soaking (60°C) for 5 hrs.	13	87	5	8	87
50.	Hot water soaking (60°C) for 7 hrs.	25	75	9	16	75
51.	Hot water soaking (60°C) for 20 hrs.	60	40	--	60	40
52.	Hot water soaking (80°C) for 4 hrs.	64	36	17	51	32
53.	Hot water soaking (80°C) for 11 hrs.	87	13	7	81	12
54.	Hot water soaking (80°C) for 20 hrs.	96	4	--	96	4
55.	Boiling water dipping	12	88	12	6	82
56.	Boiling water soaking for 5 sec.	22	78	14	10	76
57.	Boiling water soaking for 10 sec.	41	59	24	21	55
58.	Boiling water soaking for 20 sec.	40	60	32	23	45
59.	Boiling water soaking for 30 sec.	55	45	35	25	40
60.	Boiling water soaking for 1 min.	72	28	39	36	25
61.	Boiling water soaking for 2 min.	79	21	42	47	11
62.	Boiling water soaking for 5 min.	86	14	23	70	7
63.	Boiling water/ice water 5 sec.-1 time	9	91	15	10	75
64.	Boiling water/ice water 5 sec.-2 times	13	87	16	13	71
65.	Boiling water/ice water 5 sec.-5 times	21	79	19	16	65
66.	Boiling water/ice water 10 sec.-1 time	31	69	26	12	62
67.	Boiling water/ice water 10 sec.-2 times	39	61	31	15	54
68.	Boiling water/ice water 10 sec.-5 times	47	53	37	20	43
69.	Mechanical scarification (Clipping)	100	--	78	22	--
70.	Control	14	86	15	10	75

resulting in low germination and leaving a few hard seeds.

SHOCK TREATMENT :

Ten second boiling and ice water soaking was found fruitful in the seeds of this species. As the frequency of treatment was increased, percentage germination increased accordingly (37% germination at 5 times). Number of dead seeds were found more than that in control.

MECHANICAL SCARIFICATION :

Clipping the seeds showed 100% imbibition and highest (78% Vs 15% in control) germination percentage in this species. However, being the stony testa, clipping is bit difficult on the seeds of ***D. regia.***

Leucaena leucocephala. (Lot No. 30) :

HEAT TREATMENT :

As given in Table 27, soaking in water at 40°C for 12 and 24 hrs, and dry heat treatment (40°C, 60°C and 80°C) followed by 20 hrs. water soaking improved imbibition (9-21% Vs 5% in control). Germination percentage was lower and % of dead seeds became higher than that of control(5-24% Vs 1% in control), it may be due to heat injury.

CHEMICAL TREATMENT :

Pretreatment with various chemicals improved imbibition (6 to 24% Vs 5% in control). $NaNO_2$ and Thiourea gave better result (22-27% germination Vs 14% in control) while other chemicals gave poor germination (5-13% Vs

Table 27 : Percentage of imbibed, hard, germinated and dead seeds of *L. leucocephala* (Lot no. 30) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	9	91	3	7	90
2.	Seeds soaked in water (40°C) for 24 hrs.	18	82	13	6	81
3.	Seeds kept in oven at 40°C for 5 days	10	90	5	8	87
4.	Seeds kept in oven at 40°C for 10 days	12	88	5	9	86
5.	Seeds kept in oven at 60°C for 5 days	17	83	6	5	89
6.	Seeds kept in oven at 60°C for 10 days	12	88	7	8	85
7.	Seeds kept in oven at 80°C for 5 days	15	85	5	18	77
8.	Seeds kept in oven at 80°C for 10 days	11	89	3	24	73
9.	Potassium nitrate (10%) for 10 hrs.	12	88	9	8	83
10.	Potassium nitrate (10%) for 20 hrs.	13	87	13	11	76
11.	Potassium dichromate (5%) for 10 hrs.	6	94	8	2	90
12.	Potassium dichromate (5%) for 20 hrs.	9	91	9	3	88
13.	Sodium nitrite (5%) for 10 hrs.	19	81	23	15	62
14.	Sodium nitrite (5%) for 20 hrs.	25	75	22	20	58
15.	Thiourea (5%) for 10 hrs.	7	93	22	3	75
16.	Thiourea (5%) for 20 hrs.	10	90	27	5	68
17.	Cattle urine for 10 hrs.	21	79	7	23	70
18.	Cattle urine for 20 hrs.	24	76	5	27	68
19.	Mechanical scarification (Filing)	100	--	71	29	--
20.	Control	5	95	14	1	85

Table 27 : (continued) Percentage of imbibed, hard, germinated and dead seeds of *L. leucocephala* (Lot no. 30) as affected by hot water pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
21.	Hot water soaking (60°C) for 5 hrs.	8	92	60	7	33
22.	Hot water soaking (60°C) for 7 hrs.	12	88	51	10	39
23.	Hot water soaking (60°C) for 20 hrs.	17	83	70	16	14
24.	Hot water soaking (80°C) for 4 hrs.	37	63	76	24	--
25.	Hot water soaking (80°C) for 11 hrs.	65	35	61	39	--
26.	Hot water soaking (80°C) for 20 hrs.	73	27	53	47	--
27.	Mechanical scarification (Nicking)	100	--	83	17	--
28.	Mechanical scarification (Burning)	100	--	79	21	--
29.	Control	8	92	25	4	71

14 % in control). Number of dead seeds increased by each chemical (2-27% Vs 1% in control) indicating their injurious effect on the seeds.

MECHANICAL SCARIFICATION :

Hundred percent imbibition was obtained by filing in which 71% seeds germinated. This treatment seems to be the best in this table.

HOT WATER TREATMENT :

Hot water at 80°C was found to be effective for imbibition as shown in Table 27, (37 - 73% Vs 8% in control). Seeds treated with 60°C hot water for 20 hours and 80°C for 4 hours gave good results (70% and 76% germ. ,respectively Vs 25% in control). Higher temperature (80°C) for a longer time showed adverse effect as many seeds deteriorated leaving no hard seed.

MECHANICAL SCARIFICATION :

Imbibition was obtained 100% by these treatments. Nicking gave the best results (83%) while burning the seeds with hot rod gave lower germination (79%) as some seeds might have damaged by hot rod.

Leucaena leucocephala (Lot No. 31) :

ACID TREATMENT :

As given in Table 28, ten to fifteen minute soaking of seeds in conc.(98%) H_2SO_4 gave very good germination (65-80 % Vs 4% in control). As the duration of soaking increased, imbibition increased but germination decreased due to its lethal effect on the seeds. 100% imbibition was obtained by 30 minute dipping in acid.

Table 28 : Percentage of imbibed, hard, germinated and dead seeds of *L. leucocephala* (Lot no. 31) as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Concentrated (98%) H_2SO_4 for 1 min.	8	92	7	2	91
2.	Concentrated (98%) H_2SO_4 for 2 min.	17	83	16	2	82
3.	Concentrated (98%) H_2SO_4 for 3 min.	29	71	28	4	68
4.	Concentrated (98%) H_2SO_4 for 5 min.	46	54	40	6	54
5.	Concentrated (98%) H_2SO_4 for 10 min.	67	33	65	4	31
6.	Concentrated (98%) H_2SO_4 for 15 min.	82	18	80	5	15
7.	Concentrated (98%) H_2SO_4 for 30 min.	100	--	59	41	--
8.	Concentrated (98%) H_2SO_4 for 45 min.	100	--	47	53	--
9.	Diluted (50%) H_2SO_4 for 2 min.	7	93	5	2	93
10.	Diluted (50%) H_2SO_4 for 5 min.	10	90	8	3	89
11.	Diluted (50%) H_2SO_4 for 10. min.	18	82	17	4	79
12.	Diluted (50%) H_2SO_4 for 30 min.	43	57	40	7	53
13.	Diluted (50%) H_2SO_4 for 60 min.	61	39	59	6	35
14.	Diluted (50%) H_2SO_4 for 90 min.	80	20	78	7	15
15.	Diluted (50%) H_2SO_4 for 180 min.	93	7	75	21	4
16.	Diluted (10%) H_2SO_4 for 10 hrs.	5	95	4	1	95
17.	Diluted (10%) H_2SO_4 for 20 hrs.	7	93	5	2	93
18.	Diluted (10%) H_2SO_4 for 30 hrs.	11	89	9	4	87
19.	Mechanical scarification (Filing)	100	--	94	6	--
20.	Mechanical scarification (Nicking)	100	--	90	10	--
21.	Control	5	95	4	1	95

A good germination percentage was found after 90 - 180 minute treatment of diluted (50%) H_2SO_4 (75-78% Vs 4% in control) while some seeds became dead (7-21 % Vs 1% in control) leaving a few hard seeds at the end of the treatment.

Diluted (10%) H_2SO_4 was not found to be effective for germination (4 - 9% Vs 4% in control). Most of the seeds remained hard (87 - 95%) at the end of the treatment.

MECHANICAL SCARIFICATION :

Filing found to be very effective for imbibition (100%) as well as for germination percentage (94%) leaving no hard seed at the end. Nicking the seeds gave slightly lower germination percentage than filing (90% Vs 94%). It may be due to embryo injury during the process.

Leucaena leucocephala (Lot No. 32) :

CHEMICAL TREATMENTS :

As Table 29 shows, 10% KNO_3 for 20 hour duration gave better result (15% Vs 12% in control). However a number of dead seeds were found after each pretreatments. Many hard seeds remained at the end showing no effect of chemicals and cattle urine on hard seed coat of this species.

HOT WATER TREATMENT :

Hot water (60°C and 80°C) gave better imbibition after soaking for 20 hrs. in water (11-47% Vs 1% in control). Percent germination was also increased remarkably (25-76% Vs 12% in control).Seed treated with 80°C for

Table 29 : Percentage of imbibed, hard, germinated and dead seeds of *L. leucocephala* (Lot no. 32) as affected by chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Potassium nitrate (10%) for 10 hrs.	12	88	11	12	77
2.	Potassium nitrate (10%) for 20 hrs.	16	84	15	13	72
3.	Potassium dichromate (5%) for 10 hrs.	11	89	8	13	79
4.	Potassium dichromate (5%) for 20 hrs.	15	85	7	16	77
5.	Thiourea (5%) for 10 hrs.	10	90	5	11	84
6.	Thiourea (5%) for 20 hrs.	13	87	4	13	83
7.	Sodium nitrite (5%) for 10 hrs.	9	91	5	6	89
8.	Sodium nitrite (5%) for 20 hrs.	12	88	6	7	87
9.	Cattle urine for 10 hrs.	12	88	7	6	87
10.	Cattle urine for 20 hrs.	13	87	6	8	86
11.	Hot water soaking (60°C) for 5 hrs.	11	89	25	11	64
12.	Hot water soaking (60°C) for 7 hrs.	12	88	21	32	47
13.	Hot water soaking (60°C) for 20 hrs.	24	76	63	16	21
14.	Hot water soaking (80°C) for 4 hrs.	21	79	76	16	8
15.	Hot water soaking (80°C) for 11 hrs.	51	49	69	23	8
16.	Hot water soaking (80°C) for 20 hrs.	47	53	61	34	5
17.	Mechanical scarification (Filing)	100	--	88	12	--
18.	Control	1	99	12	1	87

4 hrs gave best result among the hot water treatments (76%). Treatment was found to be injurious as the duration was increased resulting a good no. of dead seeds (11-34% Vs 1% in control) leaving a few hard seeds.

MECHANICAL SCARIFICATION :

Imbibition was found to be maximum (100% Vs 1% in control) and percent germination was also highest (88% Vs 12% in control) when seeds were filed. This treatment seems to be the best in this species.

BOILING WATER TREATMENT :

As evident from the Table 30, boiling water gave fairly good results in this species. Seeds dropped in boiling water and kept in it for 5 seconds gave high germination percentages (81% and 80% Vs 9% in control). When the duration of treatment increased the percentage germination decreased and number of dead seeds increased. After 2 min. soaking no hard seed was left but many seeds became dead. Seeds tolerated boiling water upto 30 seconds giving 58% germination leaving only a few hard seeds.

SHOCK TREATMENT :

Dipping the seeds in boiling and ice water was also found fruitful in this species. Five seconds for 2 and 5 times and 10 seconds for all the times gave increasingly high germination percentage (71 to 83% Vs 9% in control). Ten second dipping for five time was excellent giving second highest percentage germination (83%).

MECHANICAL SCARIFICATION :

Clipping the individual seed imbibed all the seeds (100%) in which 13% were dead and rest 87% germinated and form seedlings. It is virtually the

Table 30 : Percentage of imbibed, hard, germinated and dead seeds of *L. leucocephala* (Lot no. 32) as affected by boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
19.	Boiling water dipping	4	96	81	9	10
20.	Boiling water soaking for 5 sec.	10	90	80	11	9
21.	Boiling water soaking for 10 sec.	19	81	77	15	8
22.	Boiling water soaking for 20 sec.	22	78	65	29	6
23.	Boiling water soaking for 30 sec.	25	75	58	39	3
24.	Boiling water soaking for 1 min.	30	70	35	64	1
25.	Boiling water soaking for 2 min.	33	67	27	73	--
26.	Boiling water soaking for 5 min.	38	62	9	91	--
	Shock treatment					
27.	Boiling water / ice water 5 sec-1 time	5	95	35	25	40
28.	Boiling water / ice water 5 sec-2 times	7	93	52	27	21
29.	Boiling water / ice water 5 sec-5 times	11	89	71	18	11
30.	Boiling water / ice water 10 sec-1 time	6	94	73	9	18
31.	Boiling water / ice water 10 sec-2 times	9	91	78	10	12
32.	Boiling water / ice water 10 sec-5 times	13	87	83	15	2
33.	Mechanical scarification (Clipping)	100	--	87	13	--
34.	Control	9	91	9	5	86

best treatment and easy to work with the seeds of *L. leucocephala.*

Parkinsonia aculeata :

HEAT TREATMENT :

As given in Table 31, soaking the seeds in water at 40°C gave better germination percentage than control (7-15% Vs 5%). Heating the seeds in oven at 40°C for 10 days gave better results (13% germination Vs 5% in control). Higher temperature and longer duration injured most of the seeds resulting low germination and increasing number of dead seeds (58-81 % Vs 59% in control).

CHEMICAL TREATMENT :

Pretreatment of seeds by various chemicals is shown in Table 31. Though percent imbibition was slightly lower (51-81% Vs 83% in control) but germination of seeds was better than control (1-9% Vs 5% in control). Percentage of dead seeds became higher than that of control (63-85% Vs 59 % in control).

Cattle urine was found to give adverse effect as germination was lower (1-4% Vs 5% in control) and number of dead seeds increased (91-96% Vs 59% in control) at the end of experiment. It seems that cattle urine injured many seeds which became dead.

MECHANICAL SCARIFICATION :

Filing gave 100% imbibition of seeds and best germination (17% Vs 5% in control) leaving no hard seed at the end of the experiment.

Table 31 : Percentage of imbibed, hard, germinated and dead seeds of *Parkinsonia aculeata* as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	87	13	15	77	8
2.	Seeds soaked in water (40°C) for 24 hrs.	92	8	7	89	4
3.	Seeds kept in oven at 40°C for 5 days	36	64	5	65	30
4.	Seeds kept in oven at 40°C for 10 days	43	57	13	66	21
5.	Seeds kept in oven at 40°C for 15 days	54	46	9	76	15
6.	Seeds kept in oven at 60°C for 5 days	41	59	7	58	35
7.	Seeds kept in oven at 60°C for 10 days	50	50	5	66	29
8.	Seeds kept in oven at 60°C for 15 days	61	39	2	81	17
9	Seeds kept in oven at 80°C for 5 days	60	40	1	72	27
10.	Seeds kept in oven at 80°C for 10 days	67	33	1	80	19
11.	Potassium nitrate (10%) for 10 hrs.	59	41	8	63	29
12.	Potassium nitrate (10%) for 20 hrs.	66	34	9	67	24
13.	Potassium dichromate (5%) for 10 hrs	76	24	8	71	21
14.	Potassium dichromate (5%) for 20 hrs	81	19	7	81	12
15.	Sodium nitrite (5%) for 10 hrs.	51	49	9	78	13
16.	Sodium nitrite (5%) for 20 hrs.	59	41	9	84	7
17.	Thiourea (5%) for 10 hrs.	67	33	7	76	17
18.	Thiourea (5%) for 20 hrs.	75	25	6	85	9
19.	Cattle urine for 10 hrs.	77	23	4	91	5
20.	Cattle urine for 20 hrs.	81	19	1	96	3
21.	Mechanical scarification (Filing)	100	--	18	82	--
22.	Control	83	17	8	59	33

ACID TREATMENT :

Table 32 shows that, 10-15 min. soaking of seeds in conc. (98%) H_2SO_4 gave better germination (17-19% Vs 7% in control). Number of hard seeds gradually decreased as the soaking time increased (17-1%), while number of dead seeds increased with increase in soaking time beyond 10 minutes.

Soaking the seeds in diluted (50%) H_2SO_4 for 30 minute gave better germination (13%) than in control (7%). Treatment more than 90 minute duration found to be harmful giving only 5% germination and 94% dead seeds.

Diluted (10%) H_2SO_4 gave better germination (15 - 17%) in 10 to 20 hour duration than that of control (7%). Many seeds remained hard after dilute (50% and 10%) H_2SO_4 treatment for various durations. Percent germination was also better to that of control. This showed that dilute H_2SO_4 did not cause damage to the seeds of ***Parkinsonia aculeata.***

MECHANICAL SCARIFICATION :

100% imbibition was obtained by both the mechanical scarifications (burning and nicking) which also gave better germination percentage (17% & 18% Vs 7% in control) in this species.

HOT WATER TREATMENT :

Table 33 shows that hot water (60°C and 80°C) gave better imbibition (>90%) but germination was not good. Only 5 hr. dipping at 60°C gave better result than the control(10% Vs 6% in control). Increasing temperature and duration gradually reduced the number of hard seeds.

Table 32 : Percentage of imbibed, hard, germinated and dead seeds of *P. aculeata* as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
23.	Concentrated (98%) H_2SO_4 for 1 min.	79	21	5	78	17
24.	Concentrated (98%) H_2SO_4 for 2 min.	81	19	7	77	16
25.	Concentrated (98%) H_2SO_4 for 3 min.	85	15	9	79	12
26.	Concentrated (98%) H_2SO_4 for 5 min.	83	17	13	75	12
27.	Concentrated (98%) H_2SO_4 for 10 min.	84	16	19	72	9
28.	Concentrated (98%) H_2SO_4 for 15 min.	85	15	17	75	8
29.	Concentrated (98%) H_2SO_4 for 30 min.	90	10	13	82	5
30.	Concentrated (98%) H_2SO_4 for 45 min.	89	11	12	84	4
31.	Concentrated (98%) H_2SO_4 for 60 min.	91	9	6	92	2
32.	Concentrated (98%) H_2SO_4 for 90 min.	93	7	4	95	1
33.	Diluted (50%) H_2SO_4 for 2 min.	79	21	6	78	16
34.	Diluted (50%) H_2SO_4 for 5 min.	81	19	7	79	14
35.	Diluted (50%) H_2SO_4 for 10 min.	82	18	7	80	13
36.	Diluted (50%) H_2SO_4 for 30 min.	85	15	13	76	11
37.	Diluted (50%) H_2SO_4 for 60 min.	86	14	9	82	9
38.	Diluted (50%) H_2SO_4 for 90 min.	87	13	8	85	7
39.	Diluted (50%) H_2SO_4 for 180 min.	89	11	5	94	1
40.	Diluted (10%) H_2SO_4 for 10 hrs.	84	16	17	75	8
41.	Diluted (10%) H_2SO_4 for 20 hrs.	89	11	15	79	6
42.	Diluted (10%) H_2SO_4 for 30 hrs.	92	8	9	86	5
43.	Mechanical scarification (Nicking)	100	--	18	82	--
44.	Mechanical scarification (Burning)	100	--	17	83	--
45.	Control	91	9	7	69	24

BOILING WATER TREATMENT :

Boiling water dipping from 5 seconds to 1 min. gave better results in this species (10% -12% Vs 6% in control). Number of hard seeds reduced gradually with increase in the duration of soaking and 100% imbibition was achieved after 1 min soaking. Seeds kept more than 2 minutes in boiling water badly injured the seeds (98% dead, 2% germinated).

SHOCK TREATMENT :

Dipping the seeds in boiling water and then in ice water gave highest percent germination (13% to 20% Vs 6% in control). Its ratio of 5 to 5 sec. for 5 times gave lowest in these treatments (13% germination). No seed was left hard after 30 seconds to 5 minute soaking in boiling water and in all the shocking treatments.

MECHANICAL SCARIFICATION :

Hundred percent imbibition was obtained by clipping in which 17% seeds were germinated. This percentage was better than that of control (6%). Rest of seeds became dead. It seems that some embryos might have damaged during clipping. In control, 15% seeds remained hard and all of them may be able to germinate or not.

Being an old seed lot, germination of ***P. aculeata*** was very low. During storage,many seeds might have become non vible due to a long period.

Table 33 : Percentage of imbibed, hard, germinated and dead seeds of *P. aculeata* as affected by hot water, boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
46.	Hot water soaking (60°C) for 5 hrs.	91	9	10	84	6
47.	Hot water soaking (60°C) for 7 hrs.	92	8	6	89	5
48.	Hot water soaking (60°C) for 20 hrs.	95	5	--	96	4
49.	Hot water soaking (80°C) for 4 hrs.	92	8	5	92	3
50.	Hot water soaking (80°C) for 11 hrs.	95	5	--	97	3
51.	Hot water soaking (80°C) for 20 hrs.	96	4	--	99	1
52.	Boiling water dipping	91	9	9	87	4
53.	Boiling water soaking for 5 sec.	92	8	10	87	3
54.	Boiling water soaking for 10 sec.	96	4	10	88	2
55.	Boiling water soaking for 20 sec.	98	2	13	87	--
56.	Boiling water soaking for 30 sec.	99	1	12	88	--
57.	Boiling water soaking for 1 min.	100	--	12	88	--
58.	Boiling water soaking for 2 min.	100	--	8	92	--
59.	Boiling water soaking for 5 min.	100	--	2	98	--
60.	Boiling water /ice water 5 sec.-1 time	93	7	20	80	--
61.	Boiling water /ice water 5 sec.-2 times	94	6	19	81	--
62.	Boiling water /ice water 5 sec.-5 times	96	4	17	83	--
63.	Boiling water /ice water 10 sec.-1 time	97	3	19	81	--
64.	Boiling water /ice water 10 sec.-2 times	99	1	18	22	--
65.	Boiling water /ice water 10 sec.-5 times	100	--	13	87	--
66.	Mechanical scarification (Clipping)	100	--	17	83	--
67.	Control	65	35	6	79	15

Pithecellobium dulce (Lot No 35) :

CHEMICAL TREATMENT :

According to Table 34, chemicals were found to be good for imbibition (75-93% Vs 25% in control) in ***P. dulce*** seeds. Thiourea (5%) gave better germination (18-21 % Vs 13 % in control) than other chemicals. After the chemical treatment some seeds remained hard at the end of experiment while in control no hard seed was left.

ACID TREATMENT :

Conc. (98%) H_2SO_4 gave better imbibition (84-100% Vs 25% in control) after 20 hr. water soaking but percentage germination was not better to that of control (7-13% Vs 13% in control).

HOT WATER TREATMENT :

Seeds soaked in hot water (60°C and 80°C) for different durations gave better imbibition(91-100% Vs 25% in control) after 20 hr. soaking but germination was almost nil. Most of the seeds became dead (98-100%) showing the sensitivity of the seeds to the heat.

MECHANICAL SCARIFICATION :

Filing gave 100% imbibition of seeds after 20 hour water soaking. Percentage germination was similar to that of control (13%) indicating the poor quality of seed lot.

Table 34 : Percentage of imbibed, hard, germinated and dead seeds of *Pithecellobium dulce* (Lot no. 35) as affected by chemical, acid and hot water pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Potassium nitrate (10%) for 10 hrs.	81	19	11	85	4
2.	Potassium nitrate (10%) for 20 hrs.	85	15	9	89	2
3.	Potassium dichromate (5%) for 10 hrs.	80	20	8	84	8
4.	Potassium dichromate (5%) for 20 hrs.	83	17	7	87	6
5.	Thiourea (5%) for 10 hrs.	78	22	18	72	10
6.	Thiourea (5%) for 20 hrs.	81	19	21	74	5
7.	Sodium nitrite (5%) for 10 hrs.	75	25	9	82	9
8.	Sodium nitrite (5%) for 20 hrs.	77	23	10	83	7
9.	Cattle urine for 10 hrs.	89	11	11	86	3
10.	Cattle urine for 20 hrs.	93	7	13	87	--
11.	Concentrated (98%) H_2SO_4 for 1 min.	84	16	13	85	2
12.	Concentrated (98%) H_2SO_4 for 3 min.	95	5	7	93	--
13.	Concentrated (98%) H_2SO_4 for 5 min.	100	--	9	91	--
14.	Hotwater soaking (60°C) for 5 hrs.	91	9	2	98	--
15.	Hot water soaking (60°C) for 7 hrs.	96	4	1	99	--
16.	Hot water soaking (60°C) for 20 hrs.	100	--	--	100	--
17.	Hot water soaking (80°C) for 4 hrs.	98	2	1	99	--
18.	Hot water soaking (80°C) for 11 hrs.	100	--	--	100	--
19.	Hot water soaking (80°C) for 20 hrs.	100	--	--	100	--
20.	Mechanical scarification (Filing)	100	--	13	87	--
21.	Control	25	75	13	87	--

Prosopis juliflora (Lot No. 39.) :

HEAT TREATMENT :

As given in Table 35, soaking the seeds in water at 40°C for 12 & 24 hrs. and dry heat treatment (for 5, 10 and 15 days at 40°, 60° and 80°C) did not show any improvement in germination. A good number of seeds were imbibed after 20 hr. water soaking (53 to 81% Vs 27 % in control). After each pretreatment germination became down (14 to 39 %) than control (69%) while the number of dead seeds was increased (21 to 69% Vs 13 % in control) leaving some hard seeds at the end of treatment.

CHEMICAL TREATMENT :

Each pretreatment with various chemicals improved the permeability of seed coat causing good imbibition (63 to 87% Vs 27% in control). Percent germination became lower (4 to 40% Vs 69% in control) because most of the seeds became dead (46 to 90% Vs 13 % in control) due to chemicals. Some hard seeds also remained at the end of the experiments.

MECHANICAL SCARIFICATION :

Filing exhibited the 100% imbibition after 20 hr. water soaking (27% in control). It increased the percent germination significantly (85% Vs 69% in control), while some seed became dead (15%) leaving no hard seed.

Table 35 : Percentage of imbibed, hard, germinated and dead seeds of *Prosopis juliflora* (Lot no. 39) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	59	41	29	40	31
2.	Seeds soaked in water (40°C) for 24 hrs.	62	38	26	45	29
3.	Seeds kept in oven at 40°C for 5 days	55	45	39	21	40
4.	Seeds kept in oven at 40°C for 10 days	67	33	33	35	32
5.	Seeds kept in oven at 40°C for 15 days	75	25	21	56	23
6.	Seeds kept in oven at 60°C for 5 days	57	43	38	21	41
7.	Seeds kept in oven at 60°C for 10 days	69	31	25	46	29
8.	Seeds kept in oven at 60°C for 15 days	81	19	14	70	16
9.	Seeds kept in oven at 80°C for 5 days	60	40	26	51	23
10.	Seeds kept in oven at 80°C for 10 days	68	32	17	69	14
11.	Potassium nitrate (10%) for 10 hrs.	77	23	35	46	19
12.	Potassium nitrate (10%) for 20 hrs.	81	19	37	51	12
13.	Potassium dichromate (5%) for 10 hrs.	63	37	6	81	13
14.	Potassium dichromate (5%) for 20 hrs.	65	35	4	92	4
15.	Sodium nitrite (5%) for 10 hrs.	75	25	27	55	18
16.	Sodium nitrite (5%) for 20 hrs.	80	20	25	60	15
17.	Thiourea (5%) for 10 hrs.	73	27	40	49	11
18.	Thiourea (5%) for 20 hrs.	79	21	37	55	8
19.	Cattle urine for 10 hrs.	83	17	10	81	9
20.	Cattle urine for 20 hrs.	87	13	6	90	4
21.	Mechanical scarification (Filing)	100	--	85	15	--
22.	Control	27	73	69	13	18

Prosopis juliflora (Lot No. 39) :

As shown in Table 36, hot water (60°C and 80°C) treatment could not improve the germination percentage of ***P. juliflora*** and it remained less than control (17 to 41% germination Vs 52% in control). Number of dead seeds were more than control after each treatment leaving lesser number of hard seeds.

BOILING WATER TREATMENT :

Dropping the seeds in boiling water and keeping the seeds in it for various durations showed no improvement in percentage germination (26% to 43% Vs 52% in control). Many seeds became dead (53% to 73% Vs 31 % in control) due to heat injury which was less effective in hot water treatment.

SHOCK TREATMENT :

Boiling and ice water dipping of seeds gave good results in ***P. juliflora.*** Five and ten second durations for two times gave better germination percentage than control (53% to 57% Vs 52% in control). Lesser number of dead seeds were observed in this treatment when compared to that of boiling and hot water pretreatments.

MECHANICAL SCARIFICATION :

Clipping the individual seeds with nail cutter imbibed all the seeds. Highest percentage germination (65%) was observed by this pretreatment showing its superiority over others.

Table 36 : Percentage of imbibed, hard, germinated and dead seeds of *Prosopis juliflora* (Lot no. 39) as affected by hot water, boiling water and shock pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
23.	Hot water soaking (60°C) for 5 hrs.	45	55	37	48	15
24.	Hot water soaking (60°C) for 7 hrs.	56	44	28	60	12
25.	Hot water soaking (60°C) for 20 hrs.	75	25	25	67	8
26.	Hot water soaking (80°C) for 4 hrs.	56	44	41	52	7
27.	Hot water soaking (80°C) for 11 hrs.	65	35	33	60	7
28.	Hot water soaking (80°C) for 20 hrs.	79	21	17	79	4
29.	Boiling water dipping	71	29	31	58	11
30.	Boiling water soaking for 5 sec.	72	28	30	57	13
31.	Boiling water soaking for 10 sec.	73	27	32	53	15
32.	Boiling water soaking for 20 sec.	75	25	32	56	12
33.	Boiling water soaking for 30 sec.	76	24	43	50	7
34.	Boiling water soaking for 1 min.	81	19	31	64	5
35.	Boiling water soaking for 2 min	83	17	28	70	2
36.	Boiling water soaking for 5 min.	86	14	26	73	1
37.	Boiling water /ice water 5 sec.-1 time	58	42	57	24	19
38.	Boiling water /ice water 5 sec.-2 times	65	35	54	31	15
39.	Boiling water /ice water 5 sec.-5 times	76	24	50	39	11
40.	Boiling water /ice water 10 sec.-1 time	61	39	55	40	5
41.	Boiling water /ice water 10 sec.-2 times	67	33	53	44	3
42.	Boiling water /ice water 10 sec.-5 times	78	22	51	47	2
43.	Mechanical scarification (Clipping)	100	--	65	35	--
44.	Control	63	37	52	31	17

Prosopis juliflora (Lot No. 40) :

HEAT TREATMENT :

As shown in Table 37, seed soaked in water of 40°C for 12 and 24 hours and dry heat condition (40°, 60° and 80°C) for 5-10 and 15 days followed by 20 hour water soaking gave a good percentage of imbibition (53% to 83% Vs 31% in control). Germination percentage was not good (9% to 48% Vs 63% in control) while the number of dead seeds was increased (23% to 51% Vs 11% in control) leaving some hard seeds also. So this treatment was good for imbibition but harmful for germination.

CHEMICAL TREATMENT :

Percentage imbibition was increased by using various chemicals (61% to 83% Vs 31% in control). Germination percentage decreased (18% to 52% Vs 63% in control), while number of dead seed was increased (32% to 69% Vs 11% in control) due to its harmful effect on seeds. Some seeds remained hard also.

MECHANICAL SCARIFICATION :

Hundred percent imbibition was shown by filing. Percentage germination was increased to 79% (63% in control) and 21% seeds became dead while in control only 11% seeds were dead and 26% were hard after the experiment.

Table 37 : Percentage of imbibed, hard, germinated and dead seeds of *Prosopis juliflora* (Lot no. 40) as affected by dry heat and chemical pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Seeds soaked in water (40°C) for 12 hrs.	79	21	48	39	13
2.	Seeds soaked in water (40°C) for 24 hrs.	83	17	45	40	15
3.	Seeds kept in oven at 40°C for 5 days	53	47	25	32	43
4.	Seeds kept in oven at 40°C for 10 days	59	41	29	38	33
5.	Seeds kept in oven at 40°C for 15 days	57	43	48	23	29
6.	Seeds kept in oven at 60°C for 5 days	59	41	9	35	56
7.	Seeds kept in oven at 60°C for 10 days	61	39	16	41	43
8.	Seeds kept in oven at 60°C for 15 days	62	38	25	43	32
9.	Seeds kept in oven at 80°C for 5 days	58	42	23	43	34
10.	Seeds kept in oven at 80°C for 10 days	63	37	19	51	30
11.	Potassium nitrate (10%) for 10 hrs.	67	33	47	33	20
12.	Potassium nitrate (10%) for 20 hrs.	75	25	52	39	9
13.	Potassium dichromate (5%) for 10 hrs.	61	39	35	43	22
14.	Potassium dichromate (5%) for 20 hrs.	69	31	33	52	15
15.	Sodium nitrite (5%) for 10 hrs.	62	38	36	41	23
16.	Sodium nitrite (5%) for 20 hrs.	68	32	35	45	20
17.	Thiourea (5%) for 10 hrs.	79	21	31	52	17
18.	Thiourea (5%) for 20 hrs.	83	17	23	69	8
19.	Cattle urine for 10 hrs.	67	33	25	53	22
20.	Cattle urine for 20 hrs.	73	27	18	69	13
21.	Mechanical scarification (Filing)	100	--	79	21	--
22.	Control	31	69	63	11	26

ACID TREATMENT :

According to Table 38, conc. (98%) H_2SO_4 showed little improvement in permeability of seed coat. Ten minute soaking of seeds gave good germination (65% Vs 48% in control). More than 30 minute duration treatment increased the number of dead seeds (up to 71% in 90 minute duration). Number of hard seeds gradually reduced with increase in the duration of treatment leaving no hard seed at the end.

Diluted (50%) H_2SO_4 treatment for 60-90 minute showed better imbibition and germianation (52% germination Vs 48% in control). Number of dead seeds increased as the time period of treatment increased (39-49% Vs 37% in control) while number of hard seeds gradually decreased.

Diluted (10%) H_2SO_4 gave almost similar imbibition (69-79% Vs 69% in control) but germination was lower (38-41% Vs 48% in control). Percentage of dead seeds increased (45 - 53% Vs 37 % in control) showing lethal effect of acid and leaving some hard seeds.

MECHANICAL SCARIFICATION :

Total seed imbibition was shown by mechanical scarification. Filing gave maximum germination (67% Vs 48%) and minimum dead seeds (33% Vs 37% in control). Burning of seeds with hot iron rod gave slightly lower germination (59%) and a little increase in dead seeds (41%) indicating its injurious effect on the seed embryo.

Table 38 : Percentage of imbibed, hard, germinated and dead seeds of *Prosopis juliflora* (Lot no. 40) as affected by acid pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
23.	Concentrated (98%) H_2SO_4 for 1 min.	73	27	46	41	13
24.	Concentrated (98%) H_2SO_4 for 2 min	76	24	48	41	11
25.	Concentrated (98%) H_2SO_4 for 3 min..	78	22	50	40	10
26.	Concentrated (98%) H_2SO_4 for 5 min.	79	21	53	38	9
27.	Concentrated (98%) H_2SO_4 for 10 min.	81	19	65	27	8
28.	Concentrated (98%) H_2SO_4 for 15 min.	80	20	57	36	7
29.	Concentrated (98%) H_2SO_4 for 30 min.	84	16	51	44	5
30.	Concentrated (98%) H_2SO_4 for 45 min.	86	13	47	50	3
31.	Concentrated (98%) H_2SO_4 for 60 min.	89	11	42	56	2
32.	Concentrated (98%) H_2SO_4 for 90 min.	92	8	29	71	--
33.	Diluted (50%) H_2SO_4 for 2 min.	62	38	37	39	24
34.	Diluted (50%) H_2SO_4 for 5 min.	69	31	41	38	21
35.	Diluted (50%) H_2SO_4 for 10 min.	73	27	43	41	16
36.	Diluted (50%) H_2SO_4 for 30 min.	81	19	49	42	9
37.	Diluted (50%) H_2SO_4 for 60 min.	85	15	52	43	5
38.	Diluted (50%) H_2SO_4 for 90 min.	89	11	51	47	2
39.	Diluted (50%) H_2SO_4 for 180 min.	93	7	50	49	1
40.	Diluted (10%) H_2SO_4 for 10 hrs.	69	31	39	45	16
41.	Diluted (10%) H_2SO_4 for 20 hrs.	76	24	41	47	12
42.	Diluted (10%) H_2SO_4 for 30 hrs.	79	21	38	53	9
43.	Mechanical scarification (Nicking)	100	--	67	33	--
44.	Mechanical scarification (Burning)	100	--	59	41	--
45.	Control	69	31	48	37	15

Prosopis juliflora (Lot No. 41) :

CHEMICAL TREATMENT :

As shown in Table 39, no chemical was found suitable to enhance germination of seeds. Germination percentage was found less than control (21-27% Vs 33% in control). However chemicals improved the imbibition which was better than control (61% to 83% Vs 33% in control) out of which a good no. of seeds became dead (64% to 78% Vs 35% in control) leaving only a few hard seeds after the treatment.

HOT WATER TREATMENT :

Good imbibition was shown when seeds were kept in various temperature and durations in hot water treatment (72-93% Vs 33% in control). Most of the imbibed seeds did not germinate and percent germination gradully decreased after 7 hrs. at 60°C. This duration gave better result than control (37 - 40 % germination Vs 33% in control). Hard seeds also decreased with increase in temperature and duration and no hard seed ramained after 4 hr. treatment at 80°C.

BOILING WATER TREATMENT :

Boiling water dip gave better imbibition (74% Vs 33% in control) and best germination (46% Vs 33% in control) in this species. A good number of seeds became dead (51% Vs 35% in control) showing poor quality of seed lot.

MECHANICAL SCARIFICATION :

Filing the seeds with hand file and soaking them in water for 20 hours resulted 100% imbibition. Highest germination percentage (51%) was obtained by this pretreatment.

Table 39 : Percentage of imbibed, hard, germinated and dead seeds of *Prosopis juliflora* (Lot no. 41) as affected by chemical and hot water pretreatments.

Pretreatments		After 20 hrs		After 15 days		
No.	Details	Imb.	Hard	Ger.	Dead	Hard
1.	Potassium nitrate (10%) for 10 hrs.	69	31	22	75	3
2.	Potassium nitrate (10%) for 20 hrs.	73	27	21	78	1
3.	Potassium dichromate (5%) for 10 hrs.	58	42	23	65	12
4.	Potassium dichromate (5%) for 20 hrs.	61	39	25	67	8
5.	Thiourea (5%) for 10 hrs.	66	34	26	64	10
6.	Thiourea (5%) for 20 hrs.	69	31	27	65	8
7.	Sodium nitrite (5%) for 10 hrs.	78	22	25	67	8
8.	Sodium nitrite (5%) for 20 hrs.	83	17	26	70	4
9.	Cattle urine for 10 hrs.	68	32	23	68	9
10.	Cattle urine for 20 hrs.	70	30	21	71	8
11.	Hot water soaking (60°c) for 5 hrs.	72	28	37	53	10
12.	Hot water soaking (60°c) for 7 hrs.	79	21	40	52	8
13.	Hot water soaking (60°c) for 20 hrs.	85	15	25	70	5
14.	Hot water soaking (80°c) for 4 hrs.	72	28	30	69	1
15.	Hot water soaking (80°c) for 11 hrs.	93	7	13	87	--
16.	Hot water soaking (80°c) for 20 hrs.	89	11	17	83	--
17.	Boiling water dipping	74	26	46	51	3
18.	Mechanical scarification (Filing)	100	--	51	49	--
19.	Control	33	67	33	35	32

MOST SUITABLE PRETREATMENTS

More than 60 pretreatments were performed on different seed lots of various species to overcome seed coat imposed dormancy. The pretreatments which performed better in a particular species/seed lot are given here as most suitable pretreatments. Performance is being assessed in terms of percentage germination as well as Germination Velocity Index.

A.auriculiformis

As shown in Table 40, the seeds of *A. **auriculiformis*** gave maximum germination by boiling water treatment for 10 sec.(45% Vs 21% in control) followed by hot water (60°C) soaking for 5 hours (44% Vs 21% in control) . Soaking the seeds in boiling water, for 20 sec. (43% germination), for 5 sec.(41% germination) and dipping in boiling water (40%) also found better than control (21%). Acid treatment for conc. (98%) H_2SO_4 for 60 min. found to be good (40% Vs 23% in control).

The maximum value of GVI was shown by boiling water treatment for 10 sec. (13.27) followed by boiling water treatment for 20 sec. (10.93). Control gave 2.9 value of GVI.

Acacia catechu (Lot no. 7):

Table 40 shows that mechanical scarification was found to be the most fruitful treatment. Filing gave 83% and nicking gave 79% germination (31% in control) . Acid treatment also found good. Scarification with conc. H_2SO_4 for 10 min. gave 75%, for 5 min. gave 73%, for 15 min. gave 72% and dil. (50%) H_2SO_4 for 60 min. gave 71% germination (31% in control). Filing

Table 40 : Percentage of Germinated, Dead and Hard seeds and GVI of *Acacia auriculiformis* and *Acacia catechu* (Lot no. 7) as affected by most suitable pretreatments.

Pretreatments					
No.	Details	Ger.	Dead	Hard	GVI
	Acacia auriculiformis				
21.	Filing(MS)	27	73	--	5.05
1.	Water soaking (40°C) for 12 hours	25	48	27	3.70
22.	Control	24	36	40	3.21
31.	Acid scarification - conc. H_2SO_4 (98%) for 60 min	40	49	11	5.83
30.	Acid Scarification - conc. H_2SO_4 (98%) for 45 min	31	54	15	3.69
32.	Acid Scarification - conc. H_2SO_4 (98%) for 90 min.	28	60	12	4.20
29.	Acid Scarification - conc. H_2SO_4 (98%) for 30 min.	27	56	17	3.08
43.	Nicking (MS)	25	75	--	3.62
45.	Control	23	53	24	3.14
54.	Boiling water soaking for 10 sec.	45	50	5	13.27
46.	Hot water(60°c) soaking for 5 hours	44	52	4	4.51
55.	Boiling water soaking for 20 sec.	43	53	4	10.93
53.	Boiling water soaking for 5 sec.	41	52	7	9.68
52.	Boiling water dipping	40	51	9	5.21
67.	Control	21	53	25	2.9
	Acacia catechu (Lot No. 7)				
18.	Filing(MS)	83	17	--	40.25
19.	Nicking(MS)	79	21	--	40.01
5.	Acid scarification conc.H_2SO_4 (98%) for 10 min.	75	25	--	38.00
4.	Acid scarification conc.H_2SO_4 (98%) for 5 min.	73	27	--	37.33
6.	Acid scarification conc.H_2SO_4 (98%) for 15 min.	72	28	--	36.00
13.	Acid scarification dil. H_2SO_4 (50%) for 60 min.	71	28	1	33.74
20.	Control	31	20	49	4.65

and nicking gave highest values of GVI (>40) while conc. acid for various duration gave 34 to 38 values of GVI in comparision to 4.65 in control.

Acacia nilotica (Lot no. 8):

As revealed by Table 41, mechanical scarification gave maximum germination (filing - 33% Vs 8% in control). Treatment of seeds with $K_2Cr_2O_7$ (5%) for 10 hours gave 21% and for 20 hours gave 17% germination .

Mechanical scarification (Filing) gave maximum value of GVI (5.75 Vs 1.26 in control).

Acacia nilotica (Lot no. 9):

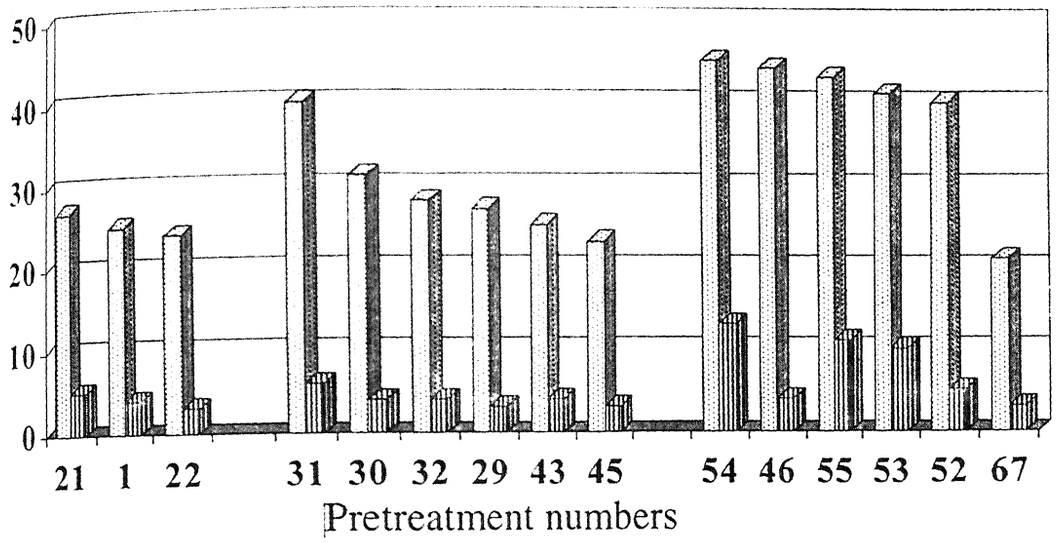
According to the Table 41, mechanical scarification (Filing) gave maximum germination (69 Vs 57% in control). Treatment of seeds with $K_2Cr_2O_7$ (5%) for 20 hrs. gave 65% and thiourea (5%) for 10 hours gave 61% germination (57% in control).

Maximum value of GVI was given by filing (13.61 Vs 9.8 in control).

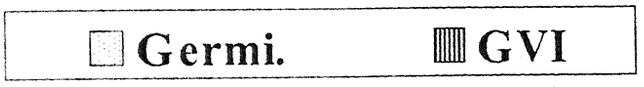
Acacia nilotica (Lot no. 11):

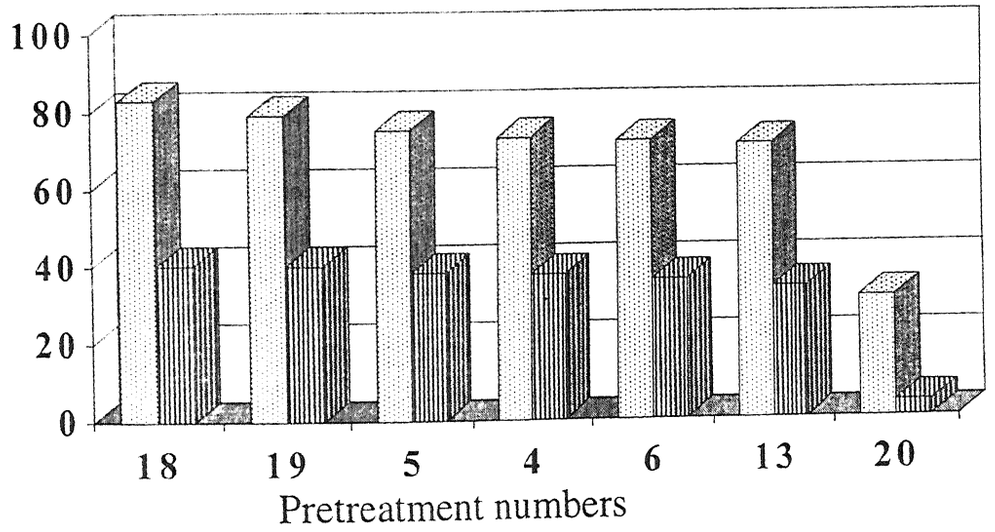
As given in Table 41, shock treatment 100°C/0°C for 10 sec.- 1 time gave 93% (59% in control) germination. Shock treatment for 2 times gave 91% and shock treatment for 5 sec. (1 time) gave 90% germination while clipping (MS) also gave 90% germination (59% in control).

Shock treatment of 10 sec. for 1 time gave maximum value of GVI (22.26 Vs 8.69 in control). Other shock treatments also gave good values of GVI (>16).



Acacia auriculiformis



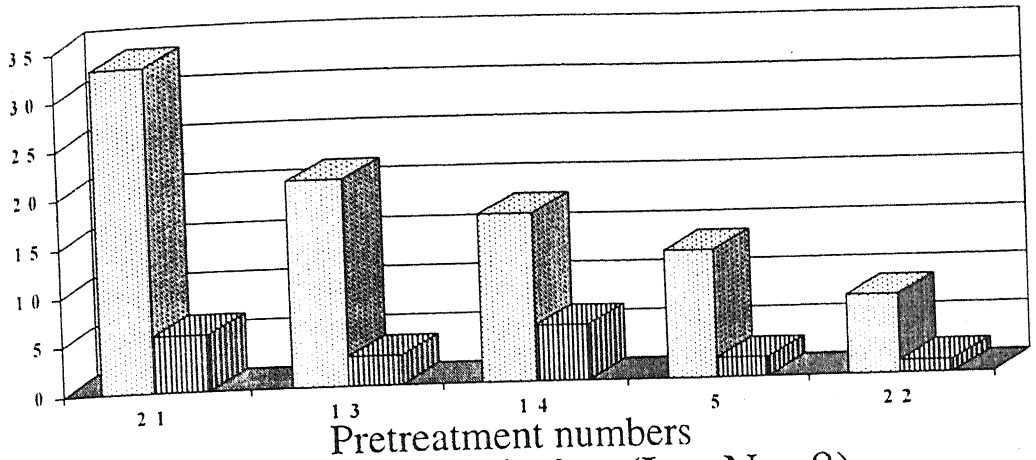


Acacia catechu

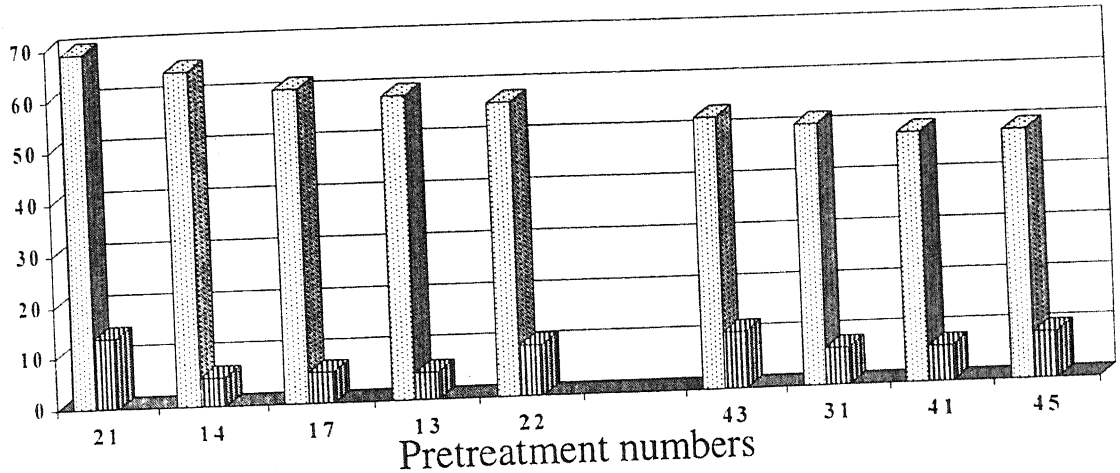
Figure 1: Germination percentage of seeds and GVI obtained after most suitable pretreatments in *A. auriculiformis* and *A. catechu* (Ref. Table 40).

Tabel 41 : Percentage of Germinated, Dead and Hard seeds and GVI of *Acacia nilotica* (Lot no 8,9 & 11) as affected by most suitable pretreatments .

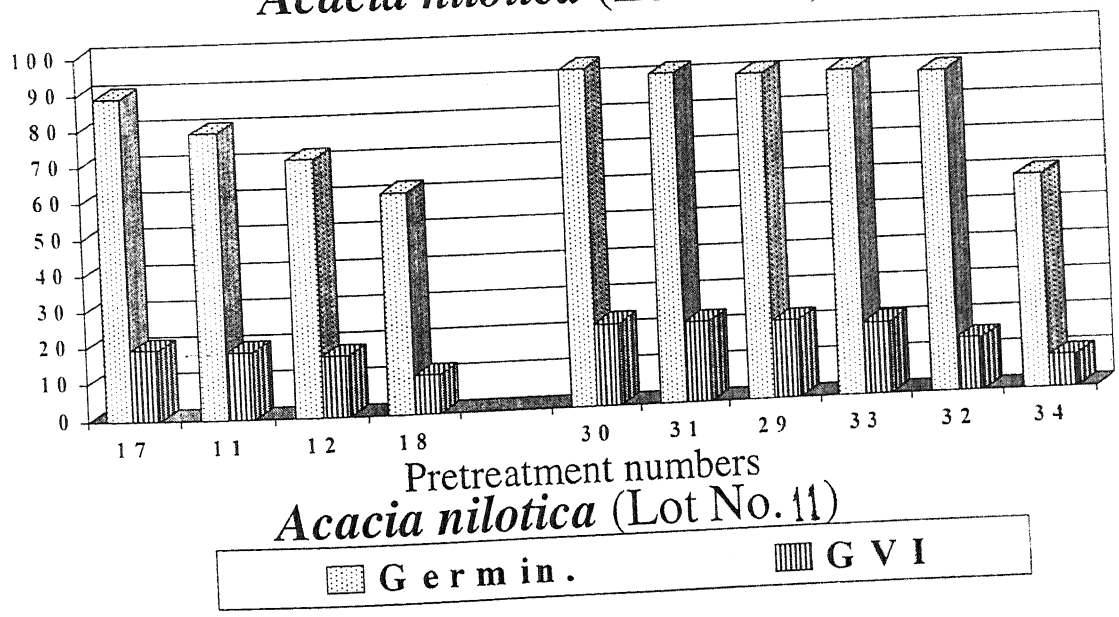
Pretreatments					
No.	Details	Ger.	Dead	Hard	GVI
	Acacia nilotica (Lot No. 8)				
21.	Filing (MS)	33	67	--	5.75
13.	Chemical treatment $K_2Cr_2O_7$ (5%) for 10 hours	21	68	11	2.9
14.	Chemical treatment $K_2Cr_2O_7$ (5%) for 20 hours	17	75	8	2.57
5.	Dry heat treatment (40°c) for 15 days	13	44	45	1.91
22.	Control	8	27	65	1.26
	Acacia nilotica (Lot No. 9)				
21.	Filing (MS)	69	31	--	13.61
14.	Chemical treatment $K_2Cr_2O_7$ (5%) for 20 hrs.	65	16	19	5.52
17.	Chemical treatment Thiourea (5%) for 10 hrs.	61	20	19	5.88
13.	Chemical treatment $K_2Cr_2O_7$ (5%) for 10 hrs.	59	15	26	5.21
22.	Control	57	18	25	9.8
43.	Nicking(MS)	53	47	--	10.93
31.	Acid scarification conc. H_2SO_4 (98%) for 60 min.	51	38	11	7.14
41.	Acid scarification dil. H_2SO_4 (10%) for 20 hrs.	49	36	15	6.84
45.	Control	49	31	20	9.01
	Acacia nilotica (Lot No. 11)				
17.	Filing	89	11	--	19.2
11.	Hot water (60°C) soaking for 5 hrs.	79	12	9	18.35
12.	Hot water (60°C) soaking for 7 hrs.	71	24	5	16.47
18.	Control	61	7	32	10.33
30.	Shock treatment 100°C/0°C for 10 sec- 1 time	93	2	5	22.26
31.	Shock treatment 100°C/0°C for 10 sec.- 2 times	91	6	3	21.84
29.	Shock treatment 100°C/0°C for 5 sec.-5 times	90	7	3	21.05
33.	Clipping (MS)	90	10	--	19.50
32.	Shock treatment 100°C/0°C for 10 sec. - 5 times	89	9	2	14.29
34.	Control	59	6	33	8.69



Acacia nilotica (Lot No. 8)



Acacia nilotica (Lot No. 9)



Acacia nilotica (Lot No. 11)

Figure 2: Germination percentage of seeds and GVI obtained after most suitable pretreatments in *A. nilotica* (Lot No. 8,9&11) (Ref. Table 41).

Albizia lebbek:

Table 42 indicated that filing gave the best (65%) germination while conc. H_2SO_4 for 15 to 60 minute duration gave better germination percentage in the seeds of ***A. lebbek*** (54% to 61% germination Vs 32% in control) . Highest value of GVI (32.31) was obtained after filing while conc. H_2SO_4 for 45 min gave 29.65 value of GVI much better than control (4.35).

Cassia fistula:

All the seed lots of ***C. fistula*** well responded to various methods of mechanical scarification. Best results were obtained by filing (Lot 23 - 89% and lot 24-90%), nicking (Lot 23-85% and lot 24-86%) and clipping (Lot 25-87%) in various seed lots where control values ranged from 1% to 6% only in lot 23 and 25. Hot water (60°C) for 20, 7 and 5 hour duration were found to give better results. In seed lot 24, treatments of seeds with H_2SO_4 for 45 to 90 min. gave better result. Thus conc. H_2SO_4 and hot water (60°C) are useful in this species to overcome seed dormancy (Table 42).

Highest values of GVI were obtained by various methods of mechanical scarification. Filing gave 17.66 (Vs 0.22) in lot 23 and 26.26 (Vs 0.20) in lot 25. These values were slightly higher than those given by other methods, i.e. hot water in lot 23 and acid treatment in lot 24.

Cassia siamea:

Mechanical scarification method gave best percentage germination (filing - 35%, Nicking - 33% and Clipping - 28% Vs 7% in control) in the seeds of ***C. siamea*** (Table 43). Conc. H_2SO_4 for 30 min. and 45 min. and burning the seeds also enhanced the germination (30%, 29% and 27%, respectively).

Table 42 : Percentage of Germinated, Dead and Hard seeds and GVI of *Albizia lebbek* (Lot No. 17)and *Cassia fistula* (Lot No. 23,24 & 25) as affected by most suitable pretreatments.

Pretreatments		Ger.	Dead	Hard	GVI
No.	Details				
	Albizia lebbek (Lot No. 17)				
21.	Filing(MS)	65	35	--	32.31
8.	Acid scarification conc. H_2SO_4 (98%) for 45 min.	61	39	--	29.65
9.	Acid scarification conc. H_2SO_4 (98%) for 60 min.	59	41	--	25.18
7.	Acid scarification conc. H_2SO_4 (98%) for 30 min.	57	40	3	20.47
6.	Acid scarification conc. H_2SO_4 (98%) for 15 min.	54	40	6	12.29
22.	Control	32	35	33	04.35
	Cassia fistula (Lot No. 23)				
27.	Filing (MS)	89	11	--	17.66
28.	Nicking (MS)	85	15	--	16.83
29.	Burning (MS)	81	19	--	16.00
23.	Hot water (60°C) soaking for 20 hrs.	80	20	--	14.90
22.	Hot water (60°C) soaking for 7 hrs.	75	18	7	17.17
21.	Hot water (60°C) soaking for 5 hrs.	64	16	20	10.17
30.	Control	5	4	91	0.72
	Cassia fistula (Lot No. 24)				
21.	Filing (MS)	90	10	--	26.26
22.	Nicking (MS)	86	14	--	26.05
10.	Acid scarification conc. H_2SO_4 (98%) for 90 min.	85	15	--	24.50
9.	Acid scarification conc. H_2SO_4 (98%) for 60 min.	80	11	9	20.54
8.	Acid scarification conc. H_2SO_4 (98%) for 45 min.	76	9	15	18.37
23.	Control	01	01	98	0.20
	Cassia fistula (Lot No. 25)				
21.	Clipping (MS)	87	13	--	29.75
3.	Hot water (60°C) soaking for 20 hrs.	60	40	--	13.50
2.	Hot water (60°C) soaking for 7 hrs.	53	25	22	11.60
1.	Hot water (60°C) soaking for 5 hrs.	49	12	39	09.80
6.	Hot water (80°C) soaking for 20 hrs.	41	59	--	13.0
22.	Control	6	5	89	0.91

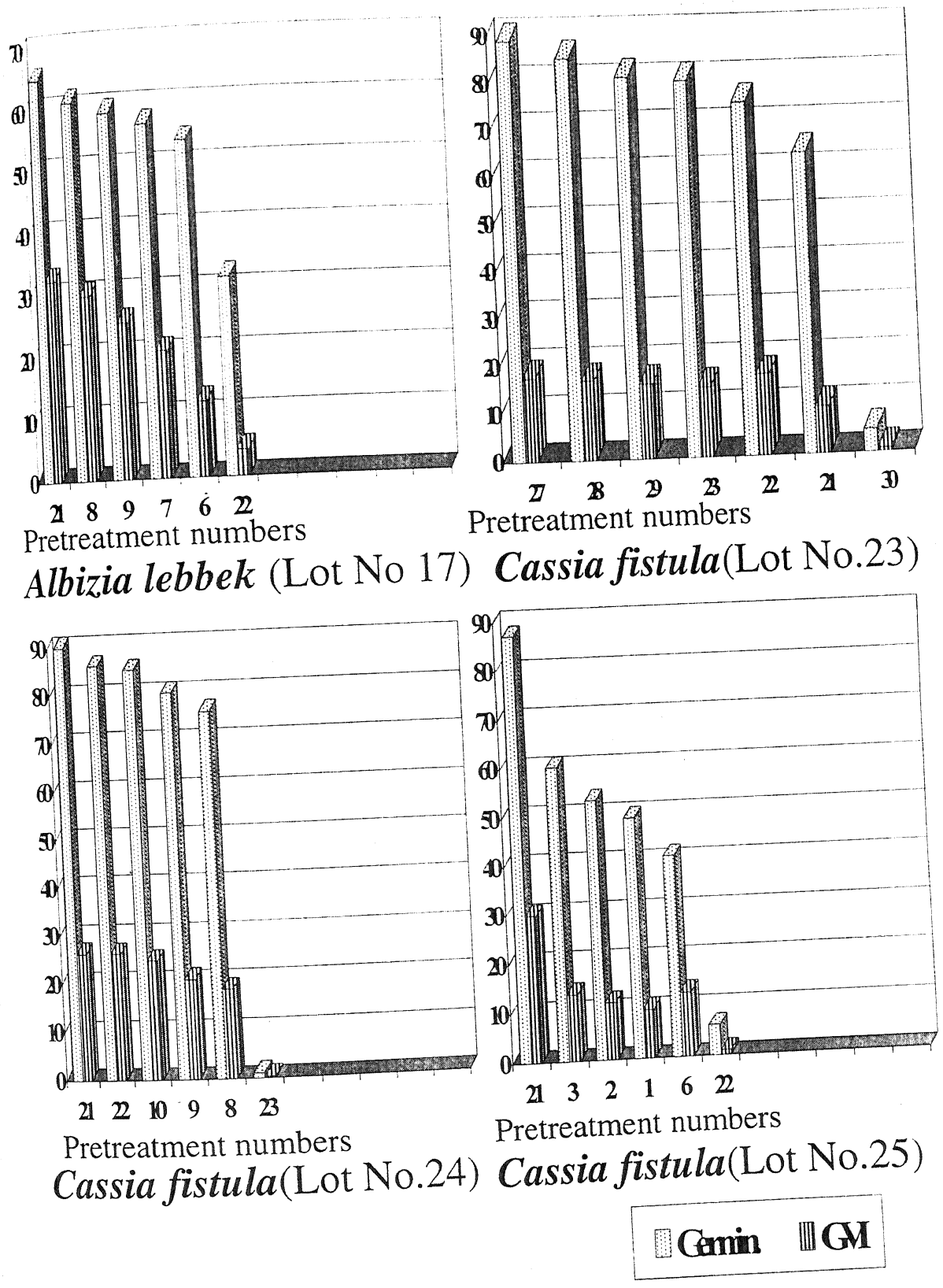
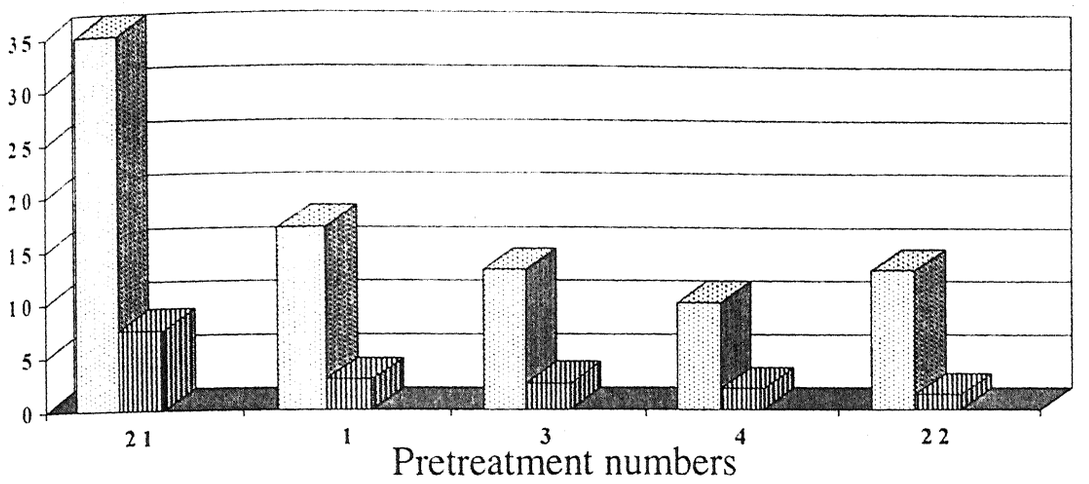
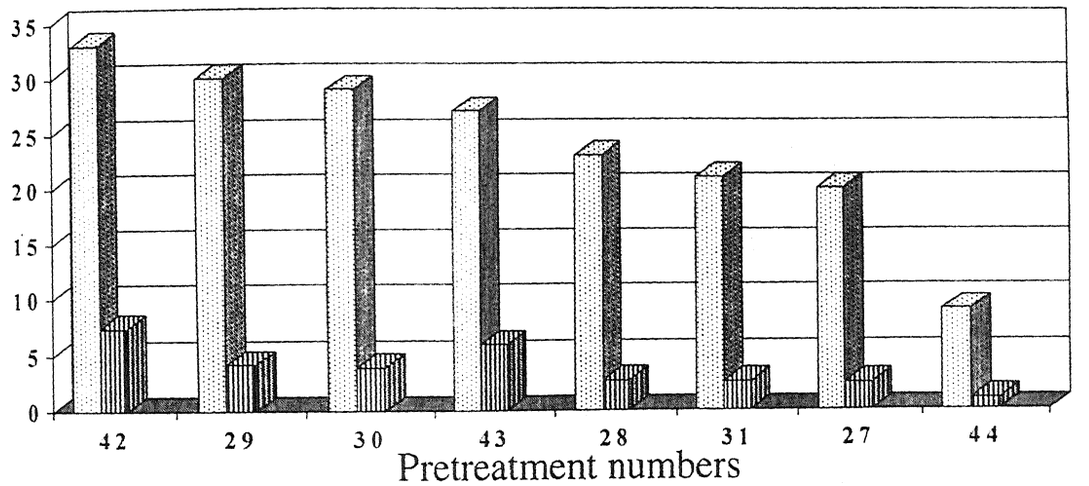


Figure 3: Germination percentage of seeds and GVI obtained after most suitable pretreatments in *Albizia lebbek* (Lot No. 17) ***Cassia fistula*** (Lot No. 23,24& 25) (Ref. Table 42).

Tabel 43 : Percentage of Germinated, Dead and Hard seeds and GVI of *Cassia siamea* as affected by most suitable pretreatments.

Pretreatments					
No.	Details	Ger.	Dead	Hard	GVI
	Cassia siamea				
21.	Filing (MS)	35	65	--	7.44
1.	Water soaking (40°C) for 12 hrs.	17	45	38	2.76
3.	Dry heat treatment (40°C) for 5 days	13	49	39	2.41
4.	Dry heat treatment (40°C) for 10 days	10	50	40	1.87
22.	Control	13	52	35	1.36
42.	Nicking (MS)	33	67	--	7.37
29.	Acid scarification conc. H_2SO_4 (98%) for 30 min.	30	67	3	4.14
30.	Acid scarification conc. H_2SO_4 (98%) for 45 min.	29	71	--	3.88
43.	Hot iron rod touching (Burning)	27	73	--	5.91
28.	Acid scarification conc. H_2SO_4 (98%) for 15 min.	23	63	14	2.68
31.	Acid scarification conc. H_2SO_4 (98%) for 60 min.	21	79	--	2.53
27.	Acid scarification conc. H_2SO_4 (98%) for 10 min.	20	63	17	2.45
44.	Control	9	59	32	1.04
64.	Clipping (MS)	28	72	--	6.25
45.	Hot water (60°C) soaking for 5 hours.	20	68	12	4.50
51.	Boiling water dipping	17	73	10	3.92
58.	Shock treatment 100°C/0°C for 5 sec - 1 time	16	76	8	4.20
52.	Boiling water, soaking for 5 sec.	15	75	10	3.42
59.	Shock treatment 100°C/0°C for 5 sec. - 2 times	15	79	6	3.83
65.	Control	7	62	31	0.90





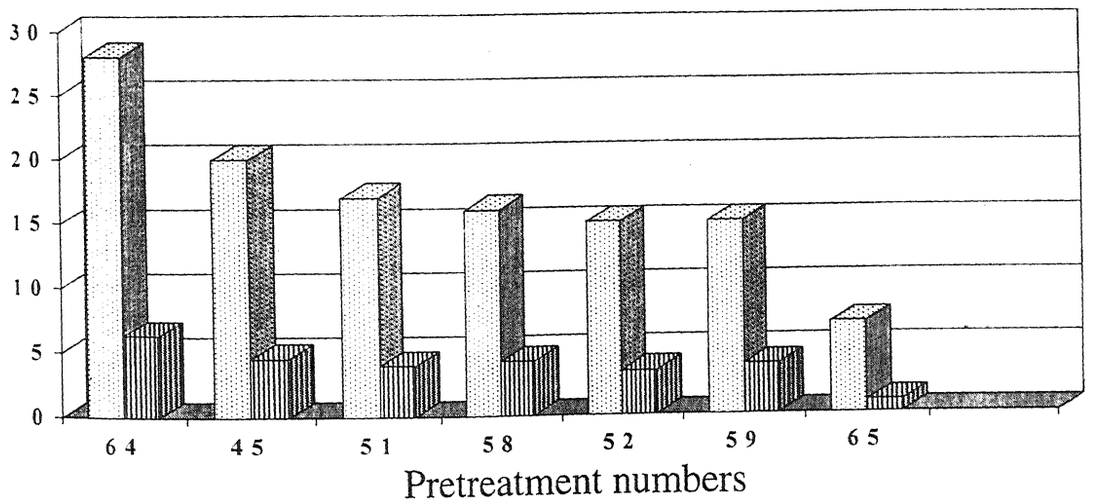


Figure 4: Germination percentage of seeds and GVI obtained after most suitable pretreatments in *Cassia siamea* (Ref. Table 43).

Highest values of GVI were obtained by various methods of mechanical scarification e.g. filing (7.44), nicking (7.37) and clipping (6.25) and burning (5.91) when compared with control (>2).

L. leucocephala:

Table 44 indicated that various mechanical scarification methods gave highest percent germination in all the seed lots of ***L. leucocephala*** (Lot 30- filing 71% Vs 14% in control; nicking 83% Vs 25% in control ; lot 31 - filing 94% and nicking 90% Vs 4% in control; and lot 32- filing 88% Vs 12% in control and clipping 87% Vs 9% in control). Hot water (80°C), boiling water for lesser duration and shock treatment also enhanced the germination in lots 30 and 32. Conc H_2SO_4 for 15 and 10 min. and dilute (50%) H_2SO_4 for 90-180 min. gave better results in lot 31. Thus hot water treatment and conc. H_2SO_4 scarification are fruitful in overcoming the seed dormancy in this species.

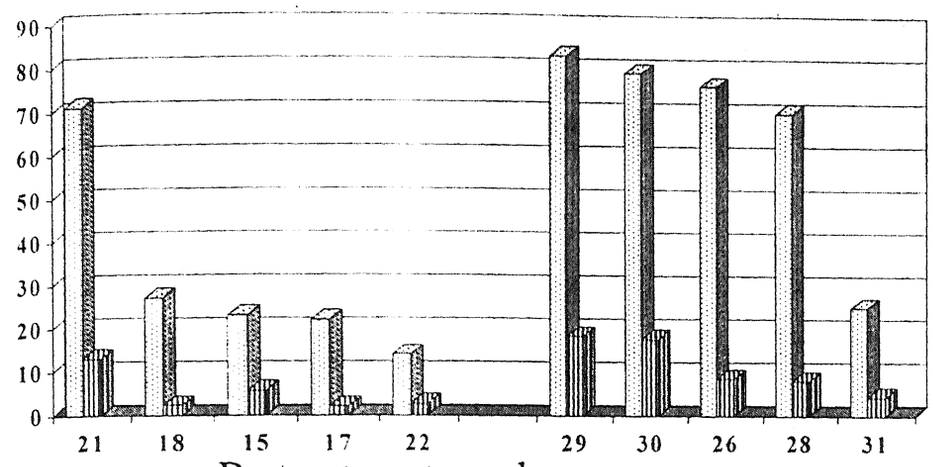
Mechanical scarifiction methods gave highest values of GVI among all the treatments of all the three rounds (Lot 30-13 Vs 2.75 in control and 18.23 and 17.57 Vs 4.31 in control; and lot 31 showed more than 41 Vs<1 in control; and lot 32-21.30 Vs 1.00 in control and 21.16 Vs 1.60 in control). Other treatments giving higher germination percentage also gave higher values of GVI but quite lower to that given by mechanical scarification methods.

Delonix regia:

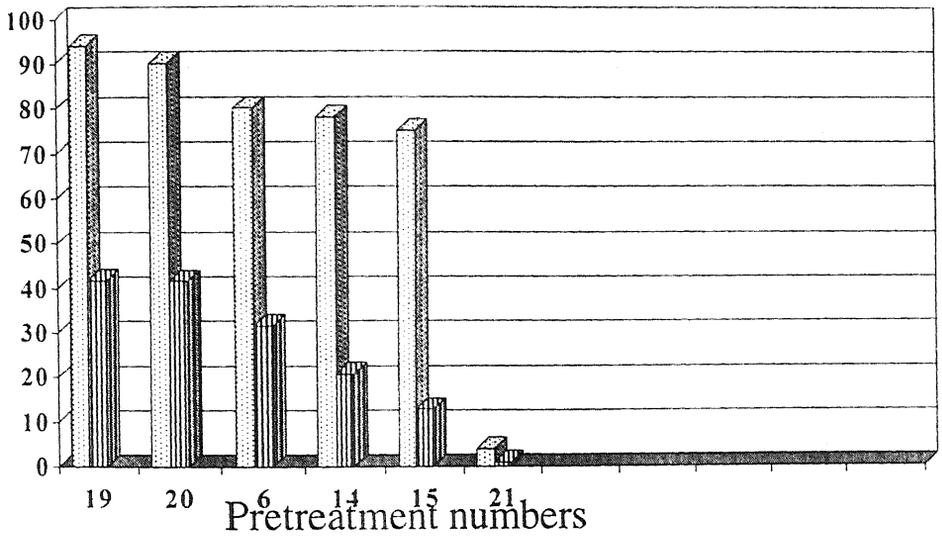
Table 45 indicated that highest percentage germination of seeds was achieved by filing of them (85%) and second highest by nicking (81%) while control values were 8% and 13%. These treatments also gave the highest values of GVI (20.83 and 20.13). Treating with H_2SO_4 for a longer time (5 and 4 hour)

Table 44 : Percentage of Germinated, Dead and Hard seeds and GVI of *Leucaena leucocephala* (Lot No. 30,31 & 32) as affected by most suitable pretreatments.

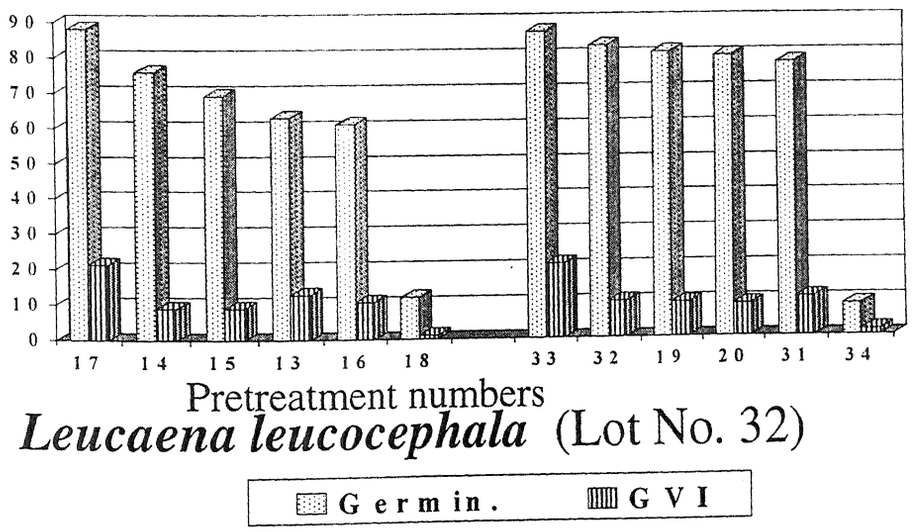
Pretreatments					
No.	Details	Ger.	Dead	Hard	GVI
	Leucaena leucocephala (Lot No. 30)				
21.	Filing (MS)	71	29	--	13.0
18.	Chemical treatment thiourea (5%) for 20 hrs	27	5	68	2.38
15.	Chemical treatment $NaNO_2$ (5%) for 10 hrs.	23	15	62	5.80
17.	Chemical treatment thiourea (5%) for 10 hrs.	22	3	75	2.10
22.	Control	14	1	85	2.75
29.	Nicking (MS)	83	17	--	18.23
30.	Burning (MS)	79	21	--	17.57
26.	Hot water (80°C) soaking for 4 hours	76	24	--	8.56
28.	Hot water (60°C) soaking for 20 hours	70	16	14	8.03
31.	Control	25	4	71	4.31
	Leucaena leucocephala (Lot No. 31)				
19.	Filing (MS)	94	6	--	41.83
20.	Nicking (MS)	90	10	--	41.59
6.	Acid scarification conc. H_2SO_4 (98%) for 15 min	80	5	15	31.64
14.	Acid scarification dil. H_2SO_4 (50%) for 90 min.	78	7	15	20.69
15.	Acid scarification dil. H_2SO_4 (50%) for 180 min.	75	21	4	12.75
21.	Control	4	1	95	0.97
	Leucaena leucocephala (Lot No. 32)				
17.	Filing	88	12	--	21.30
14.	Hot water (80°C) soaking for 4 hours	76	16	8	8.99
15.	Hot water ((80°C) soaking for 11 hours	69	22	8	8.85
13.	Hot water (60°C) soaking for 20 hours	63	16	21	12.73
16.	Hot water (80°C) soaking for 20 hours	61	34	5	10.65
18.	Control	12	1	87	1.04
33.	Clipping (MS)	87	13	--	21.16
32.	Shock treatment 100°C/0°C for 10 sec.-5 times	83	15	2	10.26
19.	Boiling water dipping	81	9	10	9.78
20.	Boiling water soaking for 5 sec.	80	12	10	9.20
31.	Shock treatment 100°C/0°C for 10 sec.-2 times	78	10	12	11.21
34.	Control	9	5	86	1.60



Leucaena leucocephala (Lot No. 30)



Leucaena leucocephala (Lot No. 31)



Leucaena leucocephala (Lot No. 32)

Figure 5: Germination percentage of seeds and GVI obtained after most suitable pretreatments in *Leucaena leucocephana* (Lot No. 30,31 & 32) (Ref. Table 44).

gave good result (80% and 72% germination Vs 13% in control) showing that seed coat of this species is extremely hard. Five hour acid treatment also gave higher value of GVI (18.57 Vs 1.8 in control).

Parkinsonia aculeata:

Being an old seed lot, many seeds of ***P. aculeata*** have lost their viability (Table-45). Dipping the seeds alternately in boiling and ice water (shock treatment) gave the best percentage germination. Five seconds - 1 time shock gave highest (20%) while other shock treatment gave 17% to 19% germination which was quite good when compared with control (6%). Conc. H_2SO_4 10 to 15 min. and filing and nicking the seeds gave 17% to 19% germination. Highest value of GVI was obtained by filing (7.5) followed by various shock treatments (5.25 to 6.3) while control value was below 2.

Pithocolobium dulce:

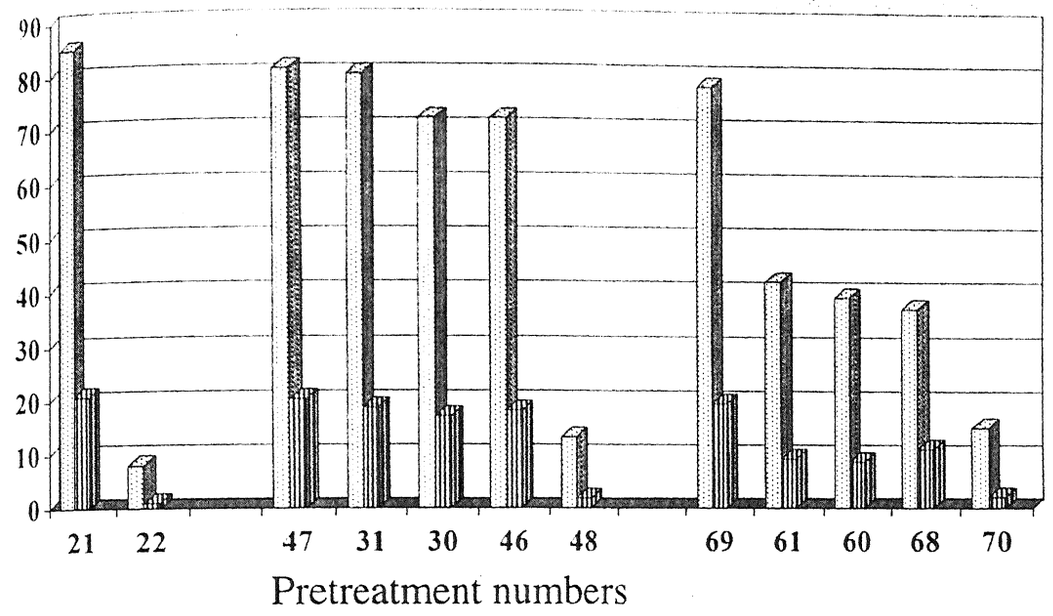
Being an old seed lot, most of the seeds of ***P. dulce*** have lost their germination power. No scarification method was found successful to enhance the percent germination in this species. Some chemicals especially thiourea initiated the weaker seeds to germinate, thus giving higher germination (18% to 21%) than control (13%). No seed was left hard in control further showing that seed coat became permeable during a long storage period (Table-46). Thiourea gave higher values of GVI (2.62 and 2.90 Vs 1.53 in control).

Prosopis juliflora

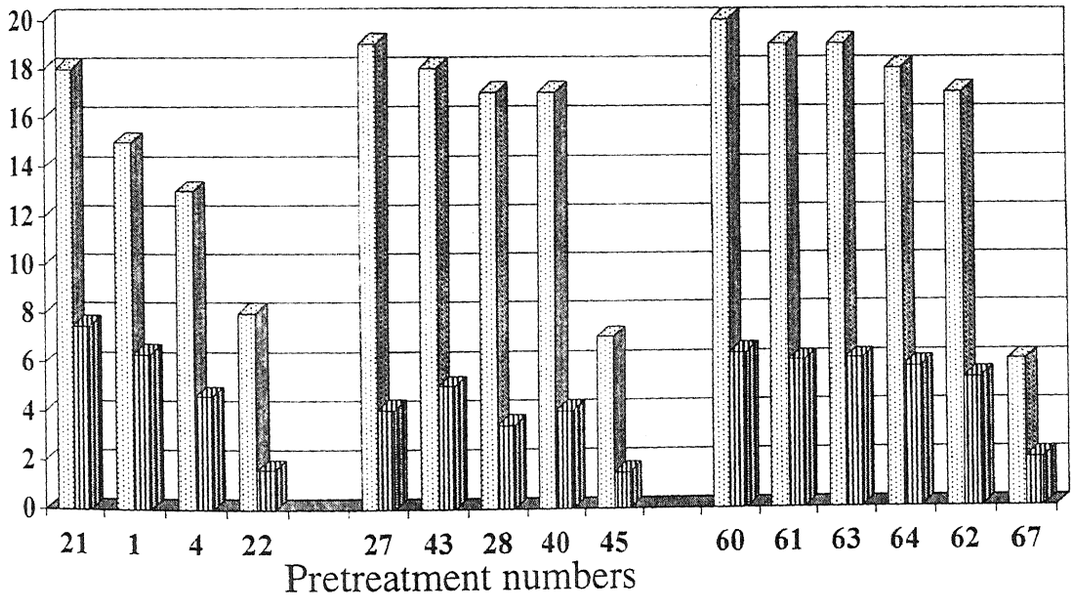
Mechanical scarification showed its superiority over other methods in this species giving higher germination percentage (Lot 39- clipping 65% Vs 52% in control; Lot 40- nicking 67% Vs 48% in control and Lot 41- 51% Vs

Tabel 45 : Percentage of Germinated, Dead and Hard seeds and GVI of *Delonix regia* (Lot No. 28) and *P. aculeata* as affected by most suitable pretreatments.

Pretreatments					
No.	Details	Ger.	Dead	Hard	GVI
	Delonix regia (Lot No. 28)				
21.	Filing (MS)	85	15	--	20.83
22.	Control	8	7	85	1.14
47.	Nicking (MS)	81	19	--	20.13
31.	Acid scarification conc. H_2SO_4 (98%) for 5 hours	80	20	--	18.57
30.	Acid scarification conc. H_2SO_4 (98%) for 4 hours	72	23	5	17.09
46.	Hot Iron rod touching (Burning)	72	28	--	18.16
48.	Control	13	8	79	1.78
69.	Clipping	78	22	--	19.30
61.	Boiling water soaking for 2 min.	42	47	11	9.14
60.	Boiling water soaking for 1 min.	39	36	25	8.66
68.	Shock treatment 100°C/0°C for 10 sec. - 5 times	37	20	43	11.0
70.	Control	15	10	75	2.0
	Parkinsonia aculeata				
21.	Filing (MS)	18	82	--	7.5
01.	Water soaking (40°C) for 12 hrs.	15	77	8	6.3
04.	Dry heat treatment (40°C) for 10 days	13	66	21	4.6
22.	Control	8	59	33	1.62
27.	Acid scarification conc. H_2SO_4 (98%) for 10 min.	19	72	9	4.04
43.	Nicking (MS)	18	82	--	5.00
28.	Acid scarification conc. H_2SO_4 (98%) for 15 min.	17	75	8	3.4
40.	Acid scarification dil. H_2SO_4 (10%) for 10 hours	17	75	8	4.0
45.	Control	7	69	24	1.48
60.	Shock treatment 100°C/0°C for 5 sec.-1 time	20	80	--	6.3
61.	Shock treatment 100°C/0°C for 5 sec.- 2 times	19	81	--	6.0
63.	Shock treatment 100°C/0°C for 10 sec.- 1 time	19	81	--	6.05
64.	Shock treatment 100°C/0°C for 10 sec. - 2 times	18	82	--	5.75
62.	Shock treatment 100°C/0°C for 5 sec. - 5 times	17	83	--	5.25
67.	Control	6	79	15	2.0



Delonix regia (Lot No. 28)

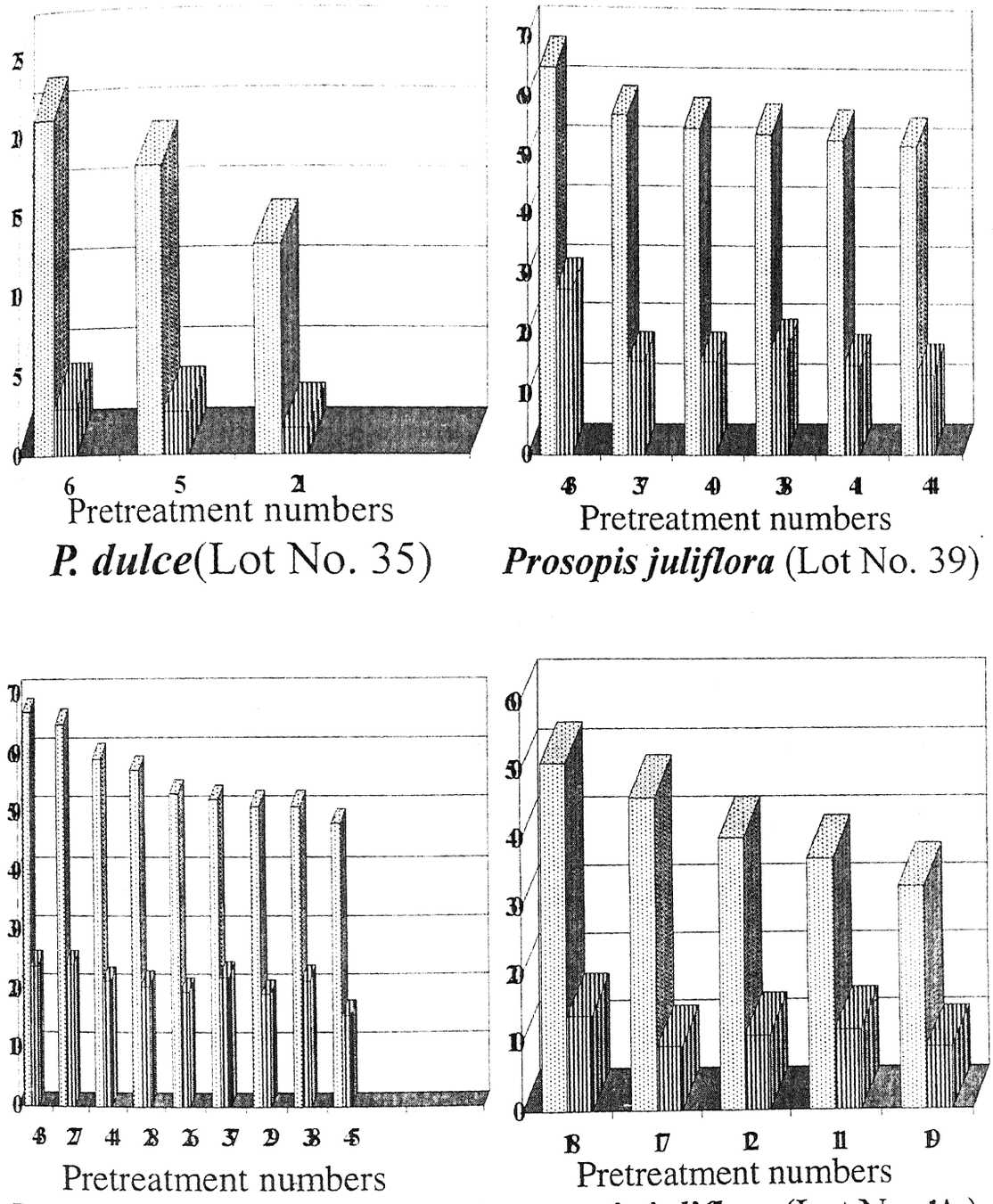


Parkinsonia aculeata

Figure 6: Germination percentage of seeds and GVI obtained after most suitable pretreatments in *Delonix regia* (Lot No. 28) and ***Parkinsonia aculeata*** (Ref. Table 45).

Table 46 : Percentage of Germinated, Dead and Hard seeds and GVI of *Pithecellobium dulce* (Lot No. 35) and *Prosopis juliflora* (Lot No. 39,40 & 41) as affected by most suitable pretreatments.

Pretreatments					
No.	Details	Ger.	Dead	Hard	GVI
	Pithecellobium dulce (Lot No. 35)				
6.	Chemical treatment - thiourea (5%) for 20 hrs.	21	74	5	2.90
5.	Chemical treatment - thiourea (5%) for 10 hrs.	18	72	10	2.62
21.	Control	13	87	--	1.53
	Prosopis juliflora (Lot No. 39)				
43.	Clipping (MS)	65	35	--	27.6
37.	Shock treatment 100°C/0°C for 5 sec. - 1 time	57	24	19	15.48
40.	Shock treatment 100°C/ 0°C for 10 sec.-1 time	55	40	5	15.48
38.	Shock treatment 100°C/ 0°C for 5 sec. - 2 times	54	31	15	17.70
41.	Shock treatment 100°C/0°C for 10 sec. - 2 times	53	44	3	15.07
44.	Control	52	31	17	13.36
	Prosopis juliflora (Lot No. 40)				
43.	Nicking (MS)	67	33	--	24.00
27.	Acid scarification conc. H_2SO_4 (98%) for 10 min.	65	27	8	24.13
44.	Burning (MS)	59	41	--	21.40
28.	Acid scarification conc. H_2SO_4 (98%) for 15 min.	57	36	7	20.50
26.	Acid scarification conc. H_2SO_4 (98%) for 5 min.	53	38	9	19.50
37.	Acid scarification dil. H_2SO_4 (50%) for 60 min.	52	43	5	22.18
29.	Acid scarification conc. H_2SO_4 (98%) for 30 min.	51	44	5	19.14
38.	Acid scarification dil. H_2SO_4 (50%) for 90 min.	51	47	2	21.5
45.	Control	48	37	15	15.56
	Prosopis juliflora (Lot No. 41)				
18.	Mechanical scarification (Filing)	51	49	--	14.0
17.	Boiling water dipping	46	51	3	9.26
12.	Hot water (60°C) soaking for 7 hours	40	52	8	11.0
11.	Hot water (60°C) soaking for 5 hours	37	53	10	11.64
19.	Control	33	35	32	9.0



P. dulce(Lot No. 35)

Prosopis juliflora (Lot No. 39)

Prosopis juliflora (Lot No.40)

Prosopis juliflora (Lot No.41)

Figure 7: Germination percentage of seeds and GVI obtained after most suitable pretreatments in *P.dulce* (Lot No. 35) and ***Prosopis juliflora*** (Lot No. 39,40 & 41) (Ref. Table 46).

33% in control). In lot 39- shock treatments for various duration gave better results (53% to 57%) than control (52%). In lot-40 conc. H_2SO_4 showed its superiority over other treatments by improving the germination from 48% (control) to 65% (1 min.) and 57% (15 min.). Boiling water and hot water were found better in lot 41 (37% to 46% germination Vs 33% in control).

Highest values of GVI were obtained in various mechanical scarification methods (Lot 39-27 Vs 13 in control; Lot 40-24 Vs 15 in control and Lot 41-14 Vs 9 in control). Acid scarification also gave higher values of GVI (20 to 24) in lot 40 of this species.

GERMINATION VELOCITY INDEX (GVI):

Speed of germination is the simplest method for testing the seed vigour. Preliminary germination counts are made at a standard time before germination is completed. The seed lot which possess largest number of germinated seeds at the preliminary count, produce the fastest growing seedlings (Dadlani,1982).

By refinement of this technique, speed of germination, germination counts are made every day upto the completion of experiment. An index of speed of germination (Germination Velocity Index) is then calculated by a simple quotient given by Agrawal (1980).

GVI values obtained after different pretreatments are shown in Table 40 to 46 and figure 1-7.

MECHANICAL SCARIFICATION:

Mechanical scarification methods (filing, nicking, clipping and burning) gave the highest GVI values in most of the species under study. In

Acacia catechu, filing and nicking gave >40 Vs 4.65 in control. In ***A. nilotica***, Lot 8 gave 5.75 (1.26 in control) while lot 9 gave 13.61 (9.01 in control) values which were highest among other treatments. ***A. lebbek*** gave 32.31 (Vs 4.35 in control) value of GVI. All the three seed lot of ***C. fistula*** (23, 24 and 25) gave highest values of GVI in filing, nicking and clipping (17.66 Vs 0.72 in control; >26 Vs 0.20 in control and 29.75 Vs 0.91 in control). Filing and nicking the seeds of ***C. siamea*** gave higher value of GVI (>7 Vs 1.3 in control). Filing and nicking the seeds of ***D. regia*** germinated early to produce seedlings, thus GVI values were higher than other pretreatments (> 20 Vs < 2 in control). Various seed lots of ***L. leucocephala*** gave highest values of GVI. Lot 30 gave 18.23 and 17.51 in nicking and burning (Vs 4.31 in control); Lot 31 gave>41 Vs<1 in control and Lot 32 gave >21 Vs <2 in filing and clipping. In ***Prosopis***, Lot 39 gave 27.6 Vs 13.36 in clipping; Lot 40 gave 24 Vs 15.56 in nicking and Lot 41 gave 14 Vs 9 in filing.

ACID SCARIFICATION:

Conc. (98%) sulphuric acid gave higher values of GVI in many species. In ***A. catechu*** conc. H_2SO_4 (98%) scarification for 10 min. gave high value of GVI 38.0 (4.65 in control) while in ***Albizia lebbek*** 45 min. duration gave good result (29.65 Vs 04.35 GVI in control). In ***C. fistula*** (Lot no. 24) 90 min. conc. H_2SO_4 gave quite high value of GVI (24.50 Vs 0.20 in control). In ***D. regia,*** 5 hr. soaking in acid gave better GVI value (18.57) than that of control (1.78). Lot no. 31 of ***L. leucocephala*** gave 31.64 GVI values Vs 0.97 in control after 15 min. treatment with this acid. In ***Prosopis,*** treatment with dil H_2SO_4 (50%) for 60 and for 90 min. gave better values of GVI (22.18 and 21.5) than

control (15.56). These results showing that treatment of seeds with conc. H_2SO_4 (98%) gave higher values of GVI than other acid treatments (Tables-40 to 46).

HOT WATER TREATMENT:

Hot water (60°C and 80°C) soaking for different periods gave better values of GVI in some species. ***A nilotica*** seeds soaking for 5 hrs. in hot water (60°C) gave 18.35 GVI Vs 10.33 in control. After 7 hour soaking in hot water (60°C) the seeds of ***C. fistula*** gave better GVI (17.17) than that of control (.72). ***Prosopis*** gave better GVI (11.64 Vs 9.0 in control) after soaking in hot water (60°C) for 5 hours.

BOILING WATER TREATMENT :

A. auriculiformis gave the best GVI (13.27 Vs 2.9 in control) by soaking the seeds in boiling water for 10 sec. followed by soaking for 20 sec. in boiling water (10.93 Vs 2.9 in control). ***D. regia*** gave better result after soaking the seeds in boiling water for 2 min. (9.14 GVI Vs 2.0 in control).

SHOCK TREATMENT:

This treatment was not found better in many species. ***A. nilotica*** (Lot no.11) gave best performance among all the treatments as 10 sec. shock for 1 and 2 times gave the best GVI (22.26 and 21.84 Vs 8.69 in control). Seeds of ***Parkinsonia*** showed better GVI by 5 sec. for 1 time and 10 sec. for 1 time (6.3 and 6.05 GVI values Vs 2.0 in control), while 5 sec. for 1 time gave better GVI (22.79) than control (13.13) in ***Prosopis juliflora***.

VIGOUR CLASSES OF SEEDLINGS:

It is an expansion of the routine germination test to classify 'normal' seedlings into 'strong' and 'weak' categories. This test is included as seedling evaluation test in the 'Hand book of Vigour Test Methods' of ISTA (Perry,1981). Mc.Donald Jr.(1980) has given emphasis on seedling vigour classification test and suggested that this test gives close results of seed vigour.

Pretreated seeds of various species when kept in water, start soaking the water and imbibe in 20 hours. When imbibed seeds are kept in germinator in controlled conditions, they start germination. First of all the radicle comes out of the seed coat (Vigour class 6). Now the seeds develop into the seedlings (Vigour classes 5 and 4) which expand their cotyledons and radicles elongate (Vigour class 3 and 2). Slowly, these develop fully grown seedlings (Vigour class 1) within a period of 10-15 days in different species. Slowly germinating seeds will produce seedlings of vigour classes 5 and 6 in the same time. Details of these stages are given in Materials and Methods and shown in Plate-6. Vigour class 1 represents a fully developed while vigour class 2 represents a well developed seedling category.

As shown in Table 47, boiling water dipping of seeds of ***A. auriculiformis*** produced maximum number of seedlings in vigour class 1 and 2 (20+9). Remaining seedlings were categorised in vigour classes 3 and 4 and no one in vigour class 6. On the other hand slowly germinating seeds (Control) could produce only 8 seedlings in vigour class 1 and 2.

In ***A. catechu*** and ***A. nilotica*** Lot 8 and 9 (Table 47) mechanical scarification of seeds produced maximum number of seedlings in vigour classes

Tabel 47 : Seedling Vigour Classes produced after some suitable pretreatments to the seeds of *A. auriculiformis*, *A. catechu* (Lot No.7) and *Albizia lebbek* (Lot No.17).

Pretreatments		S S	Seedling Vigour Classes					
No.	Details		1	2	3	4	5	6
	Acacia auriculiformis							
21.	Filing(MS)	27	14	9	4	--	--	--
1.	Water soaking (40°C) for 12 hrs.	25	3	10	7	5	--	--
22	Control	24	2	6	4	6	4	2
31	Conc. H_2SO_4 (98%) for 60 min.	40	10	14	8	4	4	--
43	Nicking (MS)	25	13	9	3	--	--	--
45	Control	23	2	6	4	7	2	2
54	Boiling water soaking for 10 min.	45	20	9	8	4	4	--
66	Clipping (MS)	25	12	10	3	--	--	--
67	Control	21	2	6	7	2	2	2
	Acacia catechu (Lot No. 7)							
18	Filing(MS)	83	35	45	3	--	--	--
5	Conc. H_2SO_4 (98%) for 10 min.	75	26	42	7	--	--	--
20	Control	31	11	5	6	3	3	3
	Albizia lebbek (Lot No. 17)							
21	Filing (MS)	65	23	19	12	8	3	--
8.	Conc. H_2SO_4 (98%) for 45 min.	61	21	17	13	6	4	--
22	Control	32	4	5	10	6	5	2

SS = Seedlings Survived (%).

Table 48: Seedling Vigour Classes produced after some suitable pretreatments to the seeds of *A.nilotica* (Lot no. 8, 9 and 11) and *C. fistula* (Lot no. 23) .

Pretreatments		S S	Seedling Vigour Classes					
No.	Details		1	2	3	4	5	6
	Acacia nilotica (Lot no. 8)							
21.	Filing (MS)	33	10	15	8	--	--	--
13.	$K_2Cr_2O_7$ (5%) for 10 hours	21	4	6	--	9	2	--
22.	Control	8	2	2	--	1	2	1
	Acacia nilotica (Lot no. 9)							
21.	Filing (MS)	69	25	32	8	4	--	--
14.	$K_2Cr_2O_7$ (5%) for 20 hours	65	--	--	20	28	15	2
22.	Control	57	15	18	16	4	3	1
43.	Nicking (MS)	53	22	30	1	--	--	--
31.	Conc. H_2SO_4 (98%) for 60 min.	51	19	26	5	1	--	--
45.	Control	49	12	15	13	5	3	1
	Acacia nilotica (Lot no. 11)							
17.	Filing (MS)	89	35	40	10	4	--	--
11.	Hot water (60°C) for 5 hours	79	33	32	9	5	--	--
18.	Control	61	12	15	16	6	7	5
	Cassia fistula (Lot no. 23)							
27.	Filing (MS)	89	16	13	25	23	10	2
23.	Hot water (60°C) for 20 hrs.	80	23	42	12	3	--	--
30.	Control	5	--	--	3	--	1	1

SS = Seedlings survived (%).

Table 49 : Seedling Vigour Classes produced after some suitable pretreatments to the seeds of *Cassia fistula* (Lot no. 24 and 25) and *Cassia siamea*.

Pretreatments		S S	Seedling Vigour Classes					
No.	Details		1	2	3	4	5	6
	Cassia fistula (Lot no. 24)							
21.	Filing (MS)	90	17	13	25	21	12	2
10.	Conc. H_2SO_4 (98%) for 90 min.	85	15	14	23	22	8	3
23.	Control	1	--	--	1	--	--	--
	Cassia fistula (Lot no. 25)							
21.	Clipping (MS)	87	15	13	25	22	10	2
3.	Hot water (60°C) for 20 hrs.	60	21	25	11	3	--	--
22.	Control	6	--	1	2	1	1	1
	Cassia siamea							
21.	Filing (MS)	35	16	8	6	5	--	--
1.	Water soaking (40°C) for 12 hrs.	17	3	3	5	4	2	--
22.	Control	13	--	--	4	4	4	1
42.	Nicking (MS)	33	15	8	7	3	--	--
22.	Conc. H_2SO_4 (98%) for 30 min.	13	2	12	16	--	--	--
44.	Control	9	--	4	2	2	1	--
64.	Clipping (MS)	28	15	11	2	--	--	--
45.	Hot water (60°C) for 5 hours	20	16	--	4	--	--	--
65.	Control	7	--	4	2	1	--	--

SS = Seedlings survived (%).

1 and 2. In Lot 11 of ***A. nilotica*** (Table 48) shock treatment initiated early growth resulting maximum number of fully grown seedling developed (45+32) within 15 days.

In ***Albizia lebbek***, mechanical scarification and acid treatment produced maximum number (42 and 38 Vs 9 in control) of fully grown seedlings (Table 47).

Table 48 and 49 showed that hot water (60°C) for 20 hours initiated the seeds of ***C. fistula*** to produce maximum number of vigorous seedlings(Lot 23-65; Lot 25-46). Mechanical scarification and acid treatment also produced vigorous seedlings. In ***C. siamea*** (Table 49) filing was found to give more vigorous seedlings than other treatments.

Table 51 indicated that mechanical scarification of seeds of ***D. regia*** produced more than 70 vigorous seedlings in 15 days while in other treatments their number was less. Acid treatment came second in this respect producing > 60 vigorous seedlings (vigour class 1 and 2).

In all the seed lots of ***L. leucocephala*** (Table 50), mechanical scarification proved its superiority over other treatments, producing largest number (>70) of seedlings in vigour class 1 and 2.

Mechanical and acid scarification and shock treatment produced more seedlings in vigour classes 1 and 2 in ***Parkinsonia*** than by other pretreatments (Table 51). Seeds of ***Pithecellobium*** being non vigorous seed lot could not produce vigorous seedlings (Table 52) in 15 days.

Table 52 indicated that mechanical scarification produced maximum number of vigorous seedlings in ***Prosopis juliflora*** (Lot 39- 65; Lot 40 - 67 and

Table 50: Seedling Vigour Classes produced after some suitable pretreatments to the seeds of *L. leucocephala* (Lot no.- 30, 31 and 32).

Pretreatments		S S	Seedling Vigour Classes					
No.	Details		1	2	3	4	5	6
	Leucaena leucocephala (Lot no. 30)							
21.	Filing (MS)	71	51	9	6	5	--	--
18.	Thiourea (5%) for 20 hrs.	27	--	2	13	8	3	1
22.	Control	14	3	4	3	2	1	1
29.	Nicking (MS)	83	65	10	8	--	--	--
26.	Hot water (80°C) for 4 hours	76	16	36	12	8	4	--
31.	Control	25	4	5	6	4	3	3
	Leucaena leucocephala (Lot no.- 31)							
19.	Filing (MS)	94	81	9	3	1	--	--
6.	Conc. H_2SO_4 (98%) for 15 min.	80	50	26	4	--	--	--
21.	Control	4	3	--	1	--	--	--
	Leucaena leucocephala (Lot no. 32)							
17.	Filing (MS)	88	75	10	2	1	--	--
14.	Hot water (80°C) for 4 hours	76	3	40	7	13	11	2
18.	Control	12	1	3	5	2	1	--
33.	Clipping (MS)	87	76	9	2	--	--	--
32.	Shock treatment for 10 sec.-5 times	83	15	10	15	22	16	5
34.	Control	9	1	2	4	2	--	--

SS = Seedlings Survived (%).

Table 51 : Seedling Vigour Classes produced after some suitable pretreatments to the seeds of *D. regia* (Lot no. 28) and *P. aculeata*.

Pretreatments		S S	Seedling Vigour Classes					
No.	Details		1	2	3	4	5	6
	Delonix regia (Lot no. 28)							
21.	Filing (MS)	86	56	15	14	--	--	--
22.	Control	8	2	--	2	2	2	--
47.	Nicking (MS)	81	55	20	6	--	--	--
31.	Conc. H_2SO_4 (98%) for 5 hours	80	32	29	19	--	--	--
48.	Control	13	2	3	--	5	2	1
69.	Clipping (MS)	78	52	20	6	--	--	--
61.	Boiling water soaking for 2 min.	42	18	11	12	1	--	--
70.	Control	15	3	4	3	3	--	2
	Parkinsonia aculeata							
21.	Filing (MS)	18	9	9	--	--	--	--
1.	Water soaking (40°C) for 12 hours	15	8	7	--	--	--	--
22.	Control	8	2	--	3	3	--	--
27.	Conc. H_2SO_4 (98%) for 10 minutes	19	12	--	4	--	3	--
43.	Nicking (MS)	18	16	2	--	--	--	--
45.	Control	7	2	--	3	2	--	--
60.	Shock treatment for 5 sec.-1 time	20	16	4	--	--	--	--
20.	Clipping	17	13	4	--	--	--	--
67.	Control	6	2	--	2	2	--	--

SS = Seedlings Survived (%).

Table 52 : Seedling Vigour Classes produced after some suitable pretreatments to the seeds of *P. dulce* (Lot no. 35) and *Prosopis juliflora* (Lot no. 39, 40 and 41).

Pretreatments		S S	Seedling Vigour Classes					
No.	Details		1	2	3	4	5	6
	Pithecellobium dulce (Lot no.35)							
6.	Thiourea (5%) for 20 hrs.	21	--	--	--	--	19	2
20.	Filing (MS)	13	--	--	2	4	5	2
21.	Control	13	--	--	--	3	6	4
	Prosopis juliflora (Lot no. 39)							
43.	Clipping (MS)	65	50	15	--	--	--	--
37.	Shock treatment for 5 sec.-1 time	57	32	17	5	3	--	--
44.	Control	52	12	20	10	5	3	2
	Prosopis juliflora (Lot no. 40)							
43.	Nicking (MS)	67	55	12	--	--	--	--
27.	Conc. H_2SO_4 (98%) for 10 min.	65	52	11	1	--	--	--
45.	Control	48	11	19	10	4	3	1
	Prosopis juliflora (Lot no. 41)							
18.	Filing (MS)	51	35	16	--	--	--	--
17.	Boiling water dipping	46	30	11	5	--	--	--
19.	Control	33	9	12	8	4	--	--

SS = Seedlings Survived (%).

Lot 41 - 51 Vs 21 - 32 in control). Acid scarification and shock treatments were other fruitful methods to obtain vigorous seedlings.

ASSESSMENT OF SEED VIABILILY BY TTC TEST:

As indicated in Table 53, viability assessed by TTC test was higher than the actual germination in *A. auriculiformis* (40%, by TTC Vs 27% germination). Seeds of *A. catechu* Lot 2, 3 and 4 had no germination but few seeds were categorised in TTC test as weak germinable. All these seeds being very old have lost the viability in bulk but a few of them still retained this power. These were categorised as weak germinable. Such seeds may germinate in the laboratory if special care/growth promotar etc. are used. Other seed lots of *A. catechu* showed germination lower than viability assessed by TTC test. Lot no. 11 and 12 were quite vigorous as reflected by TTC test as well as germination test (89 and 95% germination Vs 99 and 100% in TTC test).

Three seed lots of *Albizia lebbek* showed weak germination and most of the seeds were in non-germinable category. These seeds being very old have lost their vigour. So was the case of *A. procera* where no seed was categorised in germinable category. Lot 18 of *A. lebbek* showed excellent germination and good germinability in TTC test.

Most of the seeds of *C. fistula, C. siamea* and *D.regia* gave lower germination than assessed by TTC test. Lot 24 and 25 of *C. fistula* and lot 28 and 29 of *D. regia* were highly germinable as also assessed by TTC testing (*C. fistula* : 87 - 90% Vs 100% in TTC test; *D. regia* : 85-96% germination Vs 95 and 100% in TTC test).

Table 53 : Assessment of seed viability of various species by Tetrazolium test.

SPECIES	Seed Lot No.	Percent Germination		TTC Evaluation (%)		
		Control	Filing	G	WG	NG
Acacia auriculiformis	1	24	27	25	15	60
Acacia catechu	2	--	--	--	15	85
Acacia catechu	3	--	--	--	5	95
Acacia catechu	4	--	--	--	8	92
Acacia catechu	5	25	18	20	8	72
Acacia catechu	6	11	32	35	5	60
Acacia catechu	7	31	83	80	10	10
Acacia nilotica	8	8	33	35	11	54
Acacia nilotica	9	57	69	71	5	24
Acacia nilotica	10	31	38	40	10	50
Acacia nilotica	11	61	89	93	6	1
Acacia nilotica	12	59	95	97	3	--
Albizia lebbek	13	9	--	3	10	87
Albizia lebbek	14	1	--	--	3	97
Albizia lebbek	15	3	--	--	8	92
Albizia lebbek	16	12	8	10	5	85
Albizia lebbek	17	32	65	62	10	28
Albizia lebbek	18	49	93	95	3	2
Albizia procera	19	7	--	--	11	89
Cassia fistula	20	14	28	29	7	64
Cassia fistula	21	25	35	38	5	57

G = Germinable

WG = Weak Germinable

NG = Non Germinable

Table 53 : (continued) Assessment of seed viability of various species by Tetrazolium test.

SPECIES	Seed Lot No.	Percent Germination		TTC Evaluation (%)		
		Control	Filing	G	WG	NG
Cassia fistula	22	5	31	35	7	58
Cassia fistula	23	5	89	87	7	6
Cassia fistula	24	1	90	92	8	--
Cassia fistula	25	6	87	90	10	--
Cassia siamea	26	13	35	40	10	50
Delonix regia	27	51	65	72	6	22
Delonix regia	28	8	85	88	7	5
Delonix regia	29	6	96	93	7	--
Leucaena leucocephala	30	14	71	74	5	21
Leucaena leucocephala	31	4	94	98	2	--
Leucaena leucocephala	32	12	88	92	6	2
Parkinsonia aculeata	33	8	18	20	6	72
Pithecellobium dulce	34	--	--	--	5	95
Pithecellobium dulce	35	13	13	5	12	83
Pithecellobium dulce	36	15	81	90	7	3
Pithecellobium samen	37	4	4	2	5	97
Prosopis juliflora	38	--	--	--	7	93
Prosopis juliflora	39	69	85	90	7	3
Prosopis juliflora	40	63	79	82	5	13
Prosopis juliflora	41	33	51	60	3	47
Prosopis juliflora	42	65	92	95	3	2

G = Germinable

WG = Weak Germinable

NG = Non Germinable

All the seed lots of ***L. leucocephala*** showed germinability in both the tests, lot 31 and 32 gave good results in TTC test as well as in laboratory germination (100% and 98% in TTC test Vs 94 and 88% germination).

Seeds of ***Parkinsonia, Pithecellobium dulce*** Lot 34 and 35; ***Pithecellobium samen*** and ***Prosopis juliflora*** Lot 36 showed poor or nil germination. These seed lots were very old and thus lost their vigour. Few seeds remained viable as indicated in TTC test as weak germinable. Other seeds lots of ***Prosopis*** showed very good germination and TTC test also reflected their high germinability as most of them were found fully stained.

It seems that old seeds have deteriorated during storage. Improper storage conditions or old age may be the cause of seed deterioration. Such seeds were stained partially or got weak/faint stain during TTC test. These seeds have lost the vigour but retained the viability partially.

EFFECT OF STORAGE ON SEEDS:

Results obtained from the germination tests of variously stored seeds for 6 and 12 months indicated that air tight storage is better in most of the species, irrespective of storage temperature (Table 54). However, low temperature (5°C) was found to be better in some cases. Some seeds lost their viability when stored in paper packets.

Seeds of ***A. auriculiformis*** stored in glass bottles showed almost similar germination at room temperature and in refrigerator (≈25%) while in paper packet, there was a little decline at room temperature (20%, in 1 year) but

not that much in refrigerator (22% in 1 year).

Germination percentage of seeds of ***A. catechu,*** stored in glass bottles for **(I)** 6 months (80%) and 1 year (78%) at room temperature **(II)**-6 months (80%) and 1 year (79%) in refrigerator was almost similar. Viability of seeds stored in paper packets at room temperature (15 - 35°C) declined (76% in 6 months, 71% in 1 year), whereas it was a little impaired (79 and 76% in 6 and 12 months) in seeds stored at 5°C.

Seeds of ***A. nilotica*** showed to be resistant to various storage conditions. Their germination percentage was almost similar at 5°C in paper packets (89 and 88% in 6 and 12 months) and in glass bottles (89% in both 6 and 12 months) while a little difference at room temperature (PP - 87 and 86% in 6 and 12 months; GB - 89 and 88%) in 6 and 12 months.

Germination of ***Albizia lebbek*** seeds in paper packets declined due to absorption of moisture by them when stored at room temperature (61 and 56% in 6 and 12 months). Temperature fluctuation also affect them as glass bottles showed a little difference (63 and 60 % in 6 and 12 months). The seeds stored at 5°C showed almost same germination (PP - 63 and 62% ; GB - 64 and 63% in 6 and 12 months, respectively). Thus low and less fluctuating temperature proved to be good to maintain the viability of ***Albizia lebbek*** seeds.

Seeds of ***C. fistula*** proved to be very resistant to various storage conditions. Their germination percentage was almost unchanged after one year storgae in paper packet and glass bottles at room temperature and in refrigerator (5°C). It may be due to the resistance of seed coat which did not allow the seeds to absorb moisture when stored in paper packets at room temperature

(15 - 35°C).

C. siamea seeds stored at room temperature showed clear decline in germination. Paper packet stored seeds gave lesser germination (32 and 27% in 6 and 12 months) than glass bottles stored seeds (33 and 28% in 6 and 12 months). It might be due to effect of relative humidity and fluctating temperature on this storage condition. Seeds stored at 5°C showed better germination than that of room temperature (PP - 32 and 28 % in 6 and 12 months ; GB - 34 and 32 % in 6 and 12 months).

Like ***C. siamea,*** viability of ***Delonix regia*** seeds in paper packets showed lesser germination than in glass bottles (79 and 76 Vs 81 and 78% in 6 and 12 months) storage of room temperature. Same pattern was found in the seeds stored at 5°C but the germination was found to be better than that of room temperature storage condition. The result showed that relative humidity and fluctuating temperature of storage condition was harmful for seeds.

Seeds of ***L. leucocephala*** retained their viability in various storage condition up to 1 year, however, less fluctuating low temperature medium of storage gave better result than fluctuating high temperature. Storage of 5°C was better (PP - 81 and 77% ; GB - 80 and 81% in 6 and 12 months) than that of room temperature (PP - 80 and 75 ; GB - 83 and 79% in 6 and 12 months).

Percent germination of ***Parkinsonia*** seeds stored in paper packets, declined due to absorption of moisture by them, when stored at room temperature. However, seed coat is hard in this species but being an old seed, high relative humidity in rainy season in the atmosphere resulted in reduction of germination percentage (17 and 15% in 6 and 12 months). All other storage

Table 54: Effect of storage conditions on germination percentage of untreated hard seeds of various species.

SPECIES	Lot No.	I	STORAGE CONDITIONS							
			Room temperature (15 - 35°C)				Refrigerator (5°C)			
			6 months		12 months		6 months		12 months	
			PP	GB	PP	GB	PP	GB	PP	GB
Acacia auriculiformis	1	27	24	25	20	25	25	26	22	25
Acacia catechu	7	83	76	80	71	78	79	80	76	79
Acacia nilotica	11	89	87	89	86	88	89	89	88	89
Albizia lebbek	17	65	61	63	56	60	63	64	62	63
Cassia fistula	23	89	89	89	90	89	90	88	90	89
Cassia fistula	24	90	90	91	89	90	90	90	92	91
Cassia siamea	26	35	32	33	27	28	32	34	28	32
Delonix regia	28	85	79	81	76	78	81	83	80	82
L. leucocephala	30	71	80	83	75	79	81	80	77	81
Parkinsonia aculeata	33	18	17	18	15	17	17	18	16	18
Prosopis juliflora	39	85	60	65	52	59	64	69	62	65

I = Initial germination (unstored)

PP = Paper Packets

GB = Glass Bottles

conditions proved to be good to maintain the vaibility of ***Parkinsonia aculeata*** seeds.

Germination percentage of seeds of ***Prosopis juliflora*** stored in paper packet at room temperature (60 and 52% in 6 and 12 months) was not good. The seeds stored in refrigerator showed better germination (PP - 64 and 62% ; GB - 69 and 65% in 6 and 12 months) than that of room temperature. It might be due to effect of high RH and high temperature.

Fluctuating relative humidity (RH) during rainy season and fluctuating temperature might be responsible for the decline in percentage germination of seeds as it create deterioration of some seeds stored in permeable containers at room temperature. As the glass bottles were not permeable containers these retained the viability of seeds during storage period.

Mechanical scarification, being the best pretreatment, was applied to all the stored seeds to overcome their seed coat dormancy and make them germinable. No difference was observed in the process and duration of pretreatment in new and stored seeds in various containers and conditions

EFFECT OF STORAGE ON PRETREATED SEEDS :

As given in Table 55, storage of pretreated seeds for 6 and 12 months showed a decline in germination. Storage at low temperature (5°C) gave better results than that at room temperature.

Seeds of ***A. auriculiformis*** showed a little while seeds of ***A. catechu*** showed a clear decline (75% Vs 83% initial germination) at room temperature in one year. Only a few seeds lost their viability after one year storage in refrigerator (78% Vs 83% initial). It might be due to temperature flucuation at ambient condition.

Acacia nilotica seeds retained their viability which were stored at 5°C, but at room temperature (15 - 35°C) these seeds lost their viability a little bit (85% Vs 89% initial). Similarly seeds of ***Albizia lebbek*** showed a clear decrease in germination after one year of storage at room temperature (56% Vs 65% initial) while less decline was noticed in the seeds stored at 5°C (63 and 60% in 6 and 12 months).

Seeds of ***C. fistula*** showed almost similar germination in all the storage conditions. There was only a little change in percent germination between the seeds stored at room temperature and in refrigerator (i.e. 5°C).

Storage of ***C. siamea*** seeds at room temperature found to be more harmful after one year of storage (31 and 25 in 6 and 12 months) than the seeds stored at 5°C (32 and 30% in 6 and 12 months).

Seeds of ***D. regia*** gave same pattern of germination i.e. percent germination decreased after storage. Storage at 5°C gave better germination (82 & 81% in 6 and 12 months) than that of room temperature (80 and 77% in 6 and 12 months).

In ***L. leucocephala***, seeds showed better germination after 6 month (81%) than that of 12 months (78%) when stored at room temperature. But, almost similar germination percentage found in the seeds stored at 5°C (80 and

Table 55 : Effect of different storage conditions on germination of mechanically scarified seeds of various species.

SPECIES	Lot No.	I	STORAGE CONDITIONS			
			Room temperature (15 - 35°C)		Refrigerator (5°C)	
			6 months	12 months	6 months	12 months
Acacia auriculiformis	1	27	24	22	25	24
Acacia catechu	7	83	78	75	79	78
Acacia nilotica	11	89	88	85	88	86
Albizia lebbek	17	65	61	56	63	60
Cassia fistula	24	90	89	87	89	88
Cassia siamea	26	35	31	26	32	30
Delonix regia	28	85	80	77	82	81
L. leucocephala	30	71	81	78	80	81
P. aculeata	33	18	16	14	17	16
Prosopis juliflora	39	85	64	58	67	64

I = Initial germination (unstored)

81% in 6 and 12 months).

Parkinsonia seeds being very old gave a clear decline in percent germination when stored at room temperature (16 and 14% in 6 and 12 months). This might be due to negative effect of fluctuating temperature. Seeds stored at 5°C gave almost similar germination (17 and 16% in 6 and 12 month).

Seeds of ***Prosopis*** gave almost same germination when stored at 5°C (67 and 64% in 6 and 12 months). Less germination was found in the seeds stored at room temperature after 12 months of storage (58% in 12 months Vs 64% in 6 months).

The result showed that longer duration of storage at room temperature found to be a little harmful for germination while low temperature storage was found to be good for pretreated seeds.

CHAPTER - VI

DISCUSSION

DISCUSSION

Freshly harvested seeds of many plant species and sometimes even long stored seeds do not germinate under favourable conditions, i.e. with an adequate supply of water, oxygen, temperature and light. Such seeds may be viable but 'dormant', since germination can be induced in them by various treatments (Lovato,1981).

Impermeability of seed coats to water is most widespread cause of dormancy in family Fabaceae. Seed coats of many species of this family are very hard, resistant to abrasion and covered with a wax like layer. In nature, seed coat is broken down or punctured by abrasion, microbial attack, passing through the digestive tract of animals or due to alternating high and low temperature.

Due to rapid fluctuation in moisture and temperature, microclimate at atmosphere soil interface is always dynamic. Seeds in the vicinity of this interface, face many problems for persistance. Studies on seed coat permeability of some forest trees furnish adaptive mechanism to this dynamic microclimate. Mechanism for softening of seed coat (to make it permeable to water) generally take many years in nature. When some seeds become permeable, they germinate to produce seedlings.

Forest department and seed suppliers collect the seeds of forest trees by plucking the ripen pods from the trees. Some times fallen seeds on the ground are also collected at seeding time. Fruiting and seeding time is different in some of the trees under study i.e. ***Acacia auriculiformis, A. catechu, A.***

nilotica, Albizia lebbek, Cassia fistula, C. siamea, Delonix regia, Leucaena leucocephala, Parkinsonia aculeata, Pithecellobium dulce and *Prosopis juliflora*. Collected seeds are not exposed to the natural weathering. In nature, it is the only procedure for reducing the hardness of seed coats in these species.

Physical dormancy is caused by a hard and impermeable seed-coat which prevents imbibition and sometimes also gaseous exchange. The phenomenon is often reffered to as 'hard seed', although this term is usually reserved for impermeable seeds of Fabaceae. Because most legume trees exhibit some degree of physical dormancy, this dormancy type is by far the most common in tropical environments.

A wide range of methods has been developed to overcome this type of dormancy. All methods are derivations of the same principle; to pierce the seed-coat to an extent that will render it permeable to water so that imbibition can take place. Because the impermeability in legumes is exerted by the outer layer of the coat and palisade cells, a relatively superficial treatments may overcome dormancy in these seeds.

As the individual seeds in a seed lot vary in dormancy, adjustment of pretreatment can be difficult. Manual pretreatment of individual seeds e.g. abrasion, nicking, filing, clipping and burning is quite efficient in overcoming dormancy without damaging the seeds but is labour intensive.

Collected seeds are stored where they remain unchanged (unweathered) and whenever seedlings are to be raised from these seeds, the hard coated seeds do not germinate. They are required to be treated in some or the other way prior to sowing.

In a nursery, it is expected from a seed lot to germinate uniformly and quickly so that after a certain time all seedlings of the seed lot attain maximum hight and vigour. They are then thought to be ready for plantation in the field. Thus, number of plant per bed can be increased and time, labour and money can be saved by using properly treated seeds in the nursery.

In the present study, various physical and chemical methods have been applied to remove seed coat imposed dormancy in different species. Efficacy and validity of various pretreatments have been discussed here.

MECHANICAL SCARIFICATION:

Mechanical scarification was found to be the best pretreatment giving highest percentage germination (Table 56) in most of the seed lots under study. Imbibition was 100% after 20 hour water soaking showing its effectiveness in making the seed permeable. Very old seed lots gave negative results with this method and their percent germination was recorded lower than control. It may be due to the injury caused during filing or nicking. During nicking or clipping, endosperm or embryo get injured as reported by Sujit ***et al.*** (1994). Filing is quite easy and gives better results in most of the species. It is difficult to handle some small seeds such as ***A. auriculiformis*** and ***Prosopis juliflora,*** while delicate seeds like ***A. catechu*** and ***C. siamea*** got damage during filing. Hot iron rod touching (burning) is most delicate among various methods of mechanical scarification.

Mechanical abrasion at any one location on the seed coat would induce an almost equal effect on germination responce. The difference in optimum time of scarification treatment for maximum germination response of different

Table 56 : Percent germination of seeds of various species obtained after various methods of mechanical scarification.

Species / (Seed Lot No.)	Scarification Methods			
	Filing	Nicking	Clipping	Burning
Acacia auriculiformis	27 (24)	25 (23)	25 (21)	20 (23)
A. catechu (7)	83 (31)	79 (31)	--	--
A. nilotica (8)	33 (8)	--	--	--
A. nilotica (9)	69 (57)	53 (49)	--	48 (49)
A. nilotica (11)	89 (61)	--	90 (59)	--
Albizia lebbek	65 (32)	--	--	--
Cassia fistula (23)	89 (5)	85 (5)	--	81 (5)
C. fistula (24)	90 (1)	86 (1)	--	--
C. fistula (25)	--	--	86 (6)	--
C. siamea	35 (13)	33 (9)	28 (7)	27 (9)
Delonix regia	85 (8)	81 (13)	--	72 (13)
Leucaena leucocephala (30)	71 (14)	83 (25)	--	79 (25)
L. leucocephala (31)	94 (4)	90 (4)	--	--
L. leucocephala (32)	88 (12)	87 (9)	--	--
Parkinsonia aculeata	18 (8)	18 (7)	17 (6)	17 (7)
Pithecellobium dulce	13 (13)	--	--	--
Prosopis juliflora (39)	--	--	65 (52)	--
P. juliflora (40)	--	67 (48)	--	59 (48)
P. juliflora (41)	51 (33)	--	--	--

(Control values are in parenthes)

species suggests that a differential in seed coat is existed (Bebawi and Mohammad, 1985).

Piercing, clipping, nicking or filing the testa of individual seed with a needle, handfile or sand/iron paper is a technique especially suitable for small quantities of seed. Scarification on the shoulder of the seed one quarter of the way round the circumference from the micropyle (ISTA, 1981) or the removal of one square millimeter of seed coat at the cotyledon end is sufficient. This is usually considered to be the most reliable method of pretreatment and the percentage germination following this operation probably approximates closely to the germination capacity. However instances have been recorded when chipping the seed coat has proved determental to germination (ISTA,1985).

Many workers have successfully applied this method to break the dormancy of hard coated seeds of different species e.g. Babeley and Kandya (1984; 1985a, 1985b) in ***L. leucocephala*** and ***A. catechu***; Bebawi and Mohammad (1985) in ***Acacia***s; Chauhan (1988) in Biul; Rana and Nautiyal (1989) in ***Acacia fernesiana***; Sadhu and Kaul (1989) in ***Robinia pseudoacacia***; Singh ***et al.***(1992) in Lentil; Omari (1993) in ***Acacia***s; Sinha ***et al.*** (1993) in kasurimethi ; Todd-Bockarie and Duryea (1993) in ***Diatium*** sp.; Todd-Bockarie ***et al.*** (1993) in ***Cassia***; Bohra ***et al.*** (1994) in ***Prosopis juliflora***; Sajeevu kumar ***et al.*** (1995) in ***Albizia***; Gosling ***et al.*** (1995) in ***Leucaena leucocephala***; Keleboo ***et al.*** (1995) in MFP species; Demel (1996) in ***Senna*** species; Kannan ***et al.*** (1996) in ***Albizia*** species; Danthu ***et al.*** (1995) in ***Adansonia***; Dharmendra kumar and Pyare Lal (1999) in ***Sesbania rostrata***, Nalini and Uppar (1998) in ***Parthenium*** and Kader and Chacko (2000) in ***Thespesia populnea***.

CONCENTRATED SULPHURIC ACID TREATMENT :

Soaking in conc.(98%) H_2SO_4 is the most common method of treating hard coated seeds. The effect on the seed coat is similar to that of prolonged boiling and the seed coat is left dull and shallowly pitted. It is a more effective method than boiling water.

Seeds of ***Acacia auriculiformis*** were found to be resistant to acid scarification. Sixty minute treatment was found to be optimum (40% germination Vs 23% in control) while some seeds were found hard. Increasing duration upto 90 min. was lethal as more seeds became dead reducing germination percentage. However, some seeds still remained hard. Kandya (1990) reported that seeds of this species are very hard and require acid treatment to be soften. Padma ***et al.***(1993) reported 6 and 8 min. treatment of acid (83 and 82% germination) while Girase ***et al.*** (2002) treated the seeds of this species for 15 min. with this acid. Acoba (1987) and Marunda (1989) required 30 min. treatment to get 90% germination in this species.

Being an old seed lot (1989), ***A. auriculiformis*** require more time for acid scarification for maximum germination. Similar results were reported by Bhagat and Singh (1995) in ***Rubus ellipticus*** that fresh seeds treated with acid for 20-30 min. exhibited maximum germination, wheras stored seeds require acid treatment of 45-50 min. duration for maximum germination. Kandya (1990) has also reported 45 min acid treatment in this species to get 92% germination.

Promising percentage germination was achieved with the treatment of ***A.catechu*** (Lot 7) seeds by conc. H_2SO_4. Ten minute gave highest (75%) while 5 and 15 minute duration gave slightly lower percentages (73 and 72% respectively Vs 31% in control). No seed was left hard. Masamba (1994) reported that sulphuric acid treatment enhance germination in ***Acacia*** spp. Jerlin and Vadivelu (1994) found 10 minutes of this acid optimum in ***Acacia mellifera***. Demel (1996 a) also found this acid useful in 20 leguminous species.

Seeds of ***A. nilotica*** (Lot 9) gave slightly higher percentage germination after 60 minute treatment (51% Vs 49% in control) leaving some hard seeds. Padma ***et al.***(1993) have also reported the same duration to get maximum (92%) germination in this species. Nasim ***et al.*** (1996) and Palani ***et al.*** (1995) have also reported sulphuric acid fruitful in this species. Vankatesh ***et al.*** (2002) observed good (76%) germination (18% in control) after 60 min. acid scarification followed by water soaking.

Albizia lebbek (Lot 17) seeds gave maximum percentage germination (61% Vs 32% in control) when treated with conc. H_2SO_4 for 45 minute. Exceeding the duration resulted lower germination due to the increase in dead seeds. Babeley ***et al.*** (1986) and Padma ***et al.***(1994) have also reported the same duration of this acid treatment (i.e. 45 min.) to get better germination in this species. Bimlendra and Toky (1993) found lesser time (10 min.) while Ahmad ***et al.*** (1993) reported only two minutes to obtain better results in the same species.

C. fistula (Lot 24) seeds when kept in conc. H_2SO_4 for 90 min. gave excellent result (85% germination Vs 1% in control) leaving no hard seed. Singh

(1987) has reported that 20 minute and Babeley and Kandya (1988) reported 90 minute treatment with this acid was best in the same species while Padma *et al.* (1996) reported 2-150 minute duration of conc. H_2SO_4 in this species.

With ***C. siamea*** (Lot 26) seeds, 30 minute duration was found to give maximum germination (30% Vs 9% in control) in all the durations of acid treatment. Increasing duration lowered germination as some more seeds became dead. Kariuki (1987) also observed this acid fruitful to give enhancement in germination in this species.

Seeds of ***D. regia*** (Lot 28) responded well to conc. H_2SO_4 treatment. Eighty percent germination (13% in control) was observed when seeds were kept in it for 5 hrs. leaving no hard seeds at the end of 15 days. When duration was increased to 6 hours, all the seeds imbibed in 20 hrs. but more seeds became dead during germination. Schmidt (2000) also suggested 3-6 hrs. treatment suitable in this species but , Patel and Kukadia (1996) reported a shorter duration 5-10 min. to obtain 46-54% germination in the same species with conc. H_2SO_4.

Leucaena leucocephala (Lot 31) seeds took 15 min. in conc. H_2SO_4 to give maximum germination (80% Vs 4% in control). Duguma ***et al.*** (1988) obtained 95% germination in the same species after 30 min. treatment of seeds with this acid. Sharma and Sood (1990) reported 20 minute; Cavalcante ***et al.*** (1995) reported 40 minutes; Omokanye ***et al.*** (1995) repoted 25 minutes and Amodu ***et al.*** (2000) reported 17.5 minute duration of conc. H_2SO_4 treatment of seeds of this species to give better germination.

Parkinsonia aculeata (Lot 33) being an old seed lot responded well to 10 minute treatment with acid (19% germination Vs 7% in control). It was

the best result leaving some hard seeds. Ngulube and Chipompha (1987) recorded 100% seed germination after 20 min. treatment with the acid in this species.

Seeds of ***Prosopis juliflora*** took 10 minute to give very good results (65% germination Vs 48% in control) by acid treatment. But, Bimelendra and Toky (1993) working with the seeds of this species found that HNO_3 was better than H_2SO_4 to increase germination percentage.

Treatment with conc. H_2SO_4 provided the most rapid method of breaking dormancy. Duran and Torosa (1985) using scanning electron microscope, studied the mode of action of H_2SO_4 on seed coat of ***Sinapis arvensis***. According to them it is the rapid dessication provoked by the H_2SO_4 and not its strong ability or its high hydrolitic capacity which seems to cause the fragmentation of integuments allowing the passage of oxygen to the embryo. Bhattacharya and Saha (1990) using electron microscopy observed that disintegration of the seed coat material as well as micropylar plug may be the reason for increase in water absorption and subsequent germination of ***Cassia fistula*** seeds after concentrated sulphuric acid treatment. Bharadwaj ***et al.*** (1996) have reported in ***Robinia pseudoacacia*** that sulphuric acid seems to soften the seed coat causing uniform inflow of water and unrestricted expansion of embryo.

When seeds were kept in acid for a longer duration, more seeds were reported to become dead. It has been experienced in present study almost in all the species. Such findings have also been reported by Nguyenngoc and Rerkasem (1992) in ***Sesbania rostrata*** seeds.

BOILING WATER/HOT WATER/SHOCK TREATMENT.

A frequently used technique is to immerse the seeds in boiling water (100°C), remove the heat source, and allow the seeds to soak in gradually cooling water for 12 - 24 hrs. The optimum soaking time in boiling water varies between species. Boiling seeds in water removes the cuticle and sometimes part of the palisade layers of the seed coat and can effectively break dormancy. Boiling usually promotes germination to a critical point beyond which there is a decline in the final germination percentage. Soaking in water within the range 60 - 90°C is often as effective as soaking at 100°C but there is less chance of damage at the lower temperatures.

When suitable prescriptions have been determined, hot and boiling water methods are reasonably effective for many species, little or no special equipment or chemicals are required, the cost is negligible and with minor precautions, the technique is safe for the operator.

BOILING WATER TREATMENT :

Boiling water treatment was found to break the dormancy of seeds in some species under study.

In ***A. auriculiformis***, boiling water was found to give the best result (45% germination Vs 21% in control) when seeds were kept in it for 10 sec. Twenty sec., 5 sec. and diping the seeds in boiling water was also found to give good results (40% - 43%). Acoba (1987) also observed this treatment fruitful in the same species getting 91% germination in 1 - 3 minute duration. Dipping the seeds in boiling water and keeping them for 5 sec. enhanced the germination percentage in ***C. siamea*** (17% and 15% Vs 7% in control). In ***D. regia***, 2 min.

boiling water dip enhanced the germination from 15% (control) to 42% while 1 min. gave 39% germination. In ***L. leucocephala***, dipping and 5 sec. treatment in boiling water gave good results (81% and 80% germination respectively, Vs 9% in control). In ***Prosopis*** dipping the seeds in boiling water enhanced the germination percentage from 33% (control) to 46 percent. Ngulube and Chipompha (1987) reported 100% germination in ***Pithecellobium*** seeds by boiling water treatment. This treatment was also found to be most effective in ***Acacia*** species (Singh ***et al.***, 1990 ; Magnani ***et al.***, 1994) and in ***Cleistanthus collinus*** seeds (Sharma ***et al.***, 1999). Snehlata and Verma (1993), Todd - Boekarie and Duryea (1993), Urmila Jamwal and Dutt(1995), Chacko and Pillai (1995), Demel (1996), Sharma ***et al.*** (1999), Naidu and Mastan (2001) and Channegowda ***et al.*** (2001) also found boiling water beneficial in overcoming seed dormancy of various species.

HOT WATER TREATMENT :

Hot water was found to be effective to break seed dormancy in many plants under study. Soaking the seeds of ***A. auriculiformis*** in water (60°C) for 5 to 7 hours gave good results (44% and 38% germination respectively Vs 21% in control). Marunda (1989) reported 85% germination of seeds of this species after 5 min treatment with hot water (95°C). Seeds of ***A. nilotica*** gave 79% germination (Vs 61% in control) after 5 hrs. soaking of seed at 60°C. This temperature was also found suitable in ***C. siamea*** (5 hour - 20% germination Vs 7% in control) and ***C. fistula***. Two seed lots of ***C. fistula*** showed similar trend when kept in 60°C hot water for 20, 7 and 5 hours (Lot 23 - 80%, 75%, 64% germination Vs 5% in control ; Lot 25 - 60%, 53% and 49% germination

Vs 6% in control).

Seeds of ***L. leucocephala*** responded well when kept in hot water at 80°C and 60°C for variable periods. Both the lots, 30 and 32 showed similar trend in 80°C water soaking for 4 hours giving 76% germination by each lot which was much better than that of control (25% and 12%). When duration was enhanced, percentage germination decreased. Padma ***et al.*** (1994) found that only 5 min. soaking at 80°C the seeds of this species gave maximum germination. Gonzalez and Mendoza (1995) soaking the seeds in water at 80°C for 4 to 20 min. to get >80% germination; Omokanye ***et al.***(1995) reported 8 min. while Akino ***et al.*** (1999) found 10 minute suitable for soaking the seeds at the same (80°C) temperature in this species.

In ***Prosopis*** seeds were soaked in water at 60°C enhanced the germination from 33% to 40%. Catalan and Macchiavelli (1991) observed 70°C to 90°C suitable temperature for enhancing the germination in this species. Kundu ***et al.*** (1997) have reported that soaking the seeds in hot water (50°C) for 30 minute, gave maximum germination in ***Alstonia scholaris***.

Immersing seeds in hot water may have enhanced germination by providing a stimulatory effect on the germination process and by causing the lens tissue to rupture creating a passage through which water entered into the seeds (Marunda, 1990).

SHOCK TREATMENT-(100°C/0°C WATER SOAKING) :

Alternating temperature shock (boiling water soaking then ice water soaking) gave very good results in some species. Seeds of ***A.nilotica*** (Lot 11) gave their best performance in 10 second shock for 1 and 2 times (93 and 91%

germination Vs 59% in control). Its other treatments also affected the hard seed coat of this species making them permeable (88 to 90% germination). Nasim ***et al.*** (1996) also reported the cold shock to be fruitful in this species. Seeds of ***Leucaena*** responded well to shock treatments. Ten second duration for 2 and 5 times improved the percentage germination (78- 83% germination Vs 9% in control). In ***Parkinsonia*** all the shock treatments improved seed germination (17 to 20% Vs 6% in control). Five second for 1 time gave the best performance in this species. Seeds of ***Prosopis*** showed only a little enhancement in percentage germination by various shock treatments (53 to 57% germination Vs 52% in control). Other species did not respond to the alternating temperature (shock treatment). Other workers (Mitter ***et al.***, 1993 and Hermanson ***et al.***, 2000) have also reported that this treatment is not very effective.

CHEMICAL TREATMENT :

Among various chemicals used, thiourea and $K_2Cr_2O_7$ were found to break the seed dormancy in ***Pithecellobium*** and ***A.nilotica*** upto some extent. Thiourea is reported to increase seed germination in ***A. lebbek*** (Roy, 1992) and in ***Caesalpinia sappan*** (Channegowda ***et al.***,2001). KNO_3 and cow's urine has been reported to enhance seed germination in ***Acacia nilotica*** and in ***Albizia lebbek*** (Palani ***et al.***, 1995 and Ilango ***et al.***,1999), but during present study these chemicals along with other showed negative effect in many species making the seeds either hard or dead. Negative effect of KNO_3 has been reported in *Acacia* species (Padma ***et al.*** 1993); ***Cassia serica*** (Radhakrishnan ***et al.***, 1989); ***Vigna radiata*** (Borikar ***et al.***, 1985) and in ***Trichilia emetica*** (Msanga and Maghembe, 1993). Cattle urine also showed adverse effect in ***Buchanania***

lanzen seeds (Choubey ***et al.***, 1997). Negative effect of thiourea and cattle urine in papaya seeds has been reported by Begum ***et al.***, 1987, 1988. Sharma and Sood (1990) reported negative effect of thiourea in ***L. leucocephala*** seeds. However, in the present study thiourea enhanced the seed germination of ***Pithecellobium*** from 13% (control) to 21% which was the best result found in this species.

DRY HEAT TREATMENT:

This treatment was found to give a very little effect to some species only. Seeds of ***D. regia*** showed a little enhancement when kept at 40°C, 60°C, 80°C for 15, 10 and 10 days respectively (10% germination Vs 8% in control). In ***Parkinsonia***, storage at 40°C for 10 days gave 13% while for 15 days gave 9% germination, slightly better than that of control (8%). However, Magnani ***et al.*** (1994) reported dry heat (100°C) was effective in ***Acacia*** species. Demel (1996a) stored seeds at 60°, 80° and 100°C in oven and found fruitful in 11 out of 16 species in Ethiopia. Sacheti (1996) reported that more than 80°C dry heat exposure to the seeds of ***Acacia nilotica, Leucaena leucocephala, Parkinsonia aculeata*** and ***Prosopis juliflora*** generally affected their viability.

To avoid insect attack, seeds of ***A. lebbek*** were kept in oven at 60°C alternating temperature for about one month showed very good germination (80% Vs 49% before storage). It seems that alternating dry heat for a longer time softened the hard seed coat in this species.

DILUTE SULPHURIC ACID (50% AND 10%) :

Dilute H_2SO_4 (50%) for 60 minute moderately affected ***A. catechu*** seeds (71% germination Vs 31% in control). It was also showed some effect in

C. fistula (180 minute - 30% germination Vs 1% in control), ***L. leucocephala*** (90 minute - 78%, 180 min. - 75% Vs 4% in control) and in ***Parkinsonia*** seeds (10% acid for 10 hours - 17% germination Vs 6% in control). Eira ***et al.*** (1993) reported 75% sulphuric acid to be the most effective in breaking the seed dormancy in ***Enterolobium contortisiliqum***. When the acid is dilute, its effect is reduced thus, hard seed coat of the most of the seeds remain unaffected. Kandya (1990) reported in ***C. siamea*** that 10% dilute H_2SO_4 did not enhance the percentage germination.

PRETREATMENT AND SEED VIGOUR :

Effect of various pretreatments on the seeds of different species was reflected by imbibition and percent germination. Early and fast germination and production of fully developed seedlings at the earliest was accounted by vigour studies. Most suitable pretreatments were selected for this purpose and following two methods were applied to assess seed vigour.

GERMINATION VELOCITY INDEX:

Germination Velocity Index (GVI) is a refinement of "the speed of germination". Germination counts are made every day until germination is completed or the termination of experiment. Daily counts when divided by number of days give the value of GVI. Higher the GVI value, higher is the vigour of seed lot.

GVI is a value to denote the fastness of germination of seeds. Higher values of GVI indicate earliest germination of seeds. Performance of various pretreatments was evaluated in terms of percentage imbibition of seeds after 20 hr. water soaking and percentage germination of seeds and their GVI values.

In the present study, higher percentage germination of seeds was achieved by some suitable pretreatments in each species. Pretreatments which gave higher germination, mostly gave the higher values of Germination Velocity Index.

Mechanical scarification gave highest values of GVI in ***A. catechu***, ***A. nilotica*** (Lot 8), ***A. lebbek***, ***C. fistula***, ***C. siamea***, ***L. leucocephala*** and ***Prosopis juliflora***.

Concentrated H_2SO_4 softened the hard coated seeds to initiate them for early germination. This resulted in higher values of GVI in ***A. lebbek***, ***C. fistula*** (Lot 24), ***D. regia*** and ***L. leucocephala*** (Lot 31).

Hot water treatment gave higher values of GVI in ***C. fistula*** and ***Prosopis juliflora***. Boiling water was found effective in terms of GVI in ***A. auriculiformis*** and ***D. regia***.

Shock treatment (boiling water/ice water) gave higher values of GVI in ***A. nilotica*** (Lot 11), in ***Parkinsonia*** and in ***Prosopis juliflora***.

Mechanical scarification (filing, nicking, clipping and burning) directly permit the water to enter in the seed from scratched/burned portion of testa. Such imbibed seeds germinated quickly and produced seedlings at the earliest in comparison to those seeds which imbibed slowly.

Boiling water, acid treatment and hot water or shock treatments also softened the seed coat to permit water entry in the seed. Early imbibition resulted in early germination of seeds which ultimately form seedlings in a few days.

Thus, GVI gave an understanding of the performance of early germinated seeds. Faster germination of seeds resulted in early development

of seedlings. They ultimately developed into more vigorous plants than those developed from slowly germinating seeds. Pretreatments which softened the hard coat of seed at the earliest gave the highest values of percentage germination and GVI.

VIGOUR CLASSES OF SEEDLINGS :

Vigour classes of seedlings are virtually different stages of seedling development. When seeds germinate fastly, they develop into vigorous seedlings due to their higher potential than those which germinate later. After 15 days, seedlings of early germinated seeds could we categorised into vigour class 1and 2 while those developing from slow germinating seeds remained in vigour class 3, 4 and even some of them in 5 and 6.

It is evident from the Tables 47 to 52 that mechanical scarification (filing, nicking and clipping) of seeds enabled maximum number of seedlings to be categorised in vigour classes 1 and 2 in most of the species and seed lots taken for study. Concentrated H_2SO_4, boiling water, hot water and shock treatments were found to give excellent results in some seed lots. These pretreatments initiated the seeds to germinate early and producing fully grown seedlings in a shorter time.

ASSESSMENT OF SEED VIABILITY BY TTC TEST :

Loss of germination capacity of seed is not their death. However, it is connected with the gradual death of the embryonic tissue. TTC staining test is based on the reduction of tetrazolium salt to a red pigment 'formazan' by dehydrogenase enzyme present in the living tissue. Viable seeds obtain this red colour fully or if partly, their radicle, plumule and more than half cotyledons

attached to them are stained.

Hard seeds of old seed lots of all the species were tested for their viability by TTC test. After various pretreatments many seeds remained hard at the end of experiment in each species. These seeds when filed, decoated and kept in TTC solution, showed that many of them are to be categorised in weak-germinable/ non-germinable categories. Such seeds did not take dark red colour and many of them remained dull-coloured. Thus, it was concluded that all the hard seeds were not germinable in older seed lots. TTC test gave good results with seeds of new lots/or seeds having good viability. Most of the seeds of such lots stained in bright red colour. Recent seed lots showed excellent viability (about 100%) in many cases by tetrazolium test. Such seeds also showed >90% germination. Thus, viability of hard coated seeds was successfully assessed by TTC test. However, the assessment was slightly higher than the actual germination. Similar findings have been reported by a number of workers in various species (Smith, 1952; Gupta and Raturi, 1975; ISTA, 1983; Kandya and Babeley, 1984; Babeley and Kandya, 1989; 1990; Yu and Wang, 1996 and Padma ***et al.***, 1998).

SEED STORAGE AND PRETREATMENT :

Man wishes to sow seeds each year, while trees of many of the most desirable species from man's view point, seed irregularly. Seeds are produced often at rather long intervals, sometimes once in the life time of a plant e.g. ***Dendrocalamus*** (Troup, 1921). Storage of seeds must therefore bridge the gap and enough quantities be collected and extracted in good crop years and stored well to supply needs during the barren years.

Safe storage of seeds is important for a variety of reasons. Generally they are preserved for use as human and animal food, for industrial processing and for planting. They are protected from fire, water, insect and rodent damage. If destined for planting of seed bank use, they are also protected from loss of germination. It is apparent that healthy seed is a living stage and any living stage can convert into a dead condition due to changes in the surrrounding atmosphere and/or attack by insects, fungi, bacteria etc. In the storage, seed should be protected from these dangers. Adverse atmospheric conditions include high temperature, high relative humidity and anaerobic environment etc. In the present investigation, seeds have been tested not only to withstand some of these extremes but also their seed coat permeability relaxation in due course of time. Hard coated seeds are orthodox and have a long life span in storage. Generally their quality remains unchanged in normal storage conditions for some years. But many seeds stored for more than 10 years showed poor germination in present investigation.

As is evident from Table 54, air tight storage (glass bottles) was better than permeable containers (paper packets) in maintaining the seed viability of several species upto one year. Storage in airtight containers at low temperature found much better than other storage conditions in most of the species. Some species showed almost same germination stored in all the conditions up to one year. They were not affected by storage conditions and time periods.

Many workers have reported the storage of seeds in various conditions. Bass (1968) observed that pre-dried seeds of ***Arachis hypogea*** can be stored safely in packages of good moisture barrier materials for 3 or more years under the adverse temperature and relative humidity conditions.

Singh and Singh (1981) observed that irrespective of storage conditions, seeds of ***Carica papaya***, kept in sealed polythene bags or plastic bottles, had better germination (room temperature : 51.74% and 49.1%, cold 58.19% and 57.13%; respectivelly) than paper packets and cloth bags (room tempertature : 49.99% and 40.8% ; cold : 52.57% and 50.3% respectively) after 20 months.

Cold storage of seeds was found to be beneficial in maintaining seed viability in ***D. strictus*** stored at 3°- 5°C. After 34 months of storage seed viability was only slightly lower (59% Vs 67% initial) (Gupta and Sood, 1978).

Seeds of ***Quercus leucotrichophora*** were put in storage at 5° ±1°C, 10° ± 1°C and room temperature in polythene bags, canvas bags and tin containers. Storage at 5° ± 1°C in polythene bags proved to be the best for maintaining longevity up to 9 months, while at room temperature viability lost in 3 months (Bhardwaj ***et al.***, 2001a). Seeds of ***Ulmus laevigata*** stored in polythene bags at 5°C ±1°C maintained 62% germination after 4 months of storage (Bhardwaj ***et al.***, 2001b).

The principal external factors involve in the maintenance of viability during storage are the relative humidity (RH) and temperature of the atmosphere. Beyond these are gaseous exchange, seed coat character, maturity of seeds,

microflora and insect infestation which determine the longevity of seeds under natural or controlled storage (Barton, 1961).

Storage may be benefical for good quality seed but determental if the seed is of poor quality. The seed will probably store for longer periods without deterioration if kept at low temperature (FAO, 1983).

Moisture content of seeds at packing is probably the most important factor in determining their longevity. It was observed that longer the duration of storage, shorter the time require for imbibition when soaked in water. Hard seeds became soften in due course of time in many cases naturally during the storage but viability is also affected. Storage period of 10-15 year would result into more dead seeds but many seeds remained hard. The percentage of dead seeds increased with the longer storage duration.

STORAGE OF PRETREATED SEEDS:

Germination of hard coated seeds may extend even months or years. In order to propagate the plant in nursery it therefore is necessary to apply some form of presowing treatments to ensure rapid and uniform germination after sowing. If properly treated seeds can be stored for a considerable period without damage, they can be supplied to the nursery for sowing purpose.

As shown in Table 55, low temperature and less fluctuation of temperature gave better germination than high and fluctuating temperature. Time period of storage also affect the germination percentage. Germination percentage of pretreated seeds was found to be lower after 12 months than after 6 months. The seeds stored at 5°C in 6 months gave better germination than in all other conditions.

Pretreated seeds of ***Acacia catechu***, ***Cassia siamea*** and ***Prosopis juliflora*** were much affected when stored at room temperature for one year. While the seeds of ***A. nilotica*** and ***C. fistula*** gave almost similar germination in all the storage conditions. Pretreated seeds of ***A. lebbek***, ***D. regia*** and ***P. aculeata*** gave a little bit decline in percent germination after one year storage at room temperature.

Percent germination of pretreated seeds was decreased in ***A. auriculiformis*** and in ***A. catechu***, stored at room temperature for 12 months. Same result was given by Youssef ***et al.*** (1991) in different ***Acacia*** species. He found that germination was slightly reduced by storage of pretreated seeds for 1 years (from an average of 35.45% over all species and treatment to 31.19%) while Lawridsen and Stubsgaard (1987) have shown no decrease in the germination capacity of pretreated seeds for a sufficient time until sowing. On the other hand Ferreira ***et al.*** (1992) found an increase in percent germination of mechanically scarified stored seeds of 2 ***Acacia*** species and Sniezko and Gwaze (1987) found excellent germination after the storage of one year of sulphuric acid scarified seeds of ***Acacia albida***.

Seeds of ***Albizia lebbek*** and ***Cassia siamea*** have shown a decline in percent germination after storage of one year. Kandya (1990) has also reported decrease in germination after 18 months of storage of pretreated ***C. siamea*** seeds, but she noticed some increase after 6 months of storage.

Leucaena leucocephala seeds treated before storage showed high germination percentage after storage in all the conditions for 6 and 12 months. Similar findings have been reported in this species by Birader ***et al.*** (1988);

Duguma ***et al.*** (1988), Omokanye and Onifade (1993) and Omokanye ***et al.*** (1995). Improved germination rates was reported in pretreated seeds of ***Robinia pseudoacacia*** stored for 8 months by Laroppe ***et al.*** (1996). While Piotto and Piccini (1996) noticed no loss in percentage germination in mechanically scarified seeds of Carob stored in sealed containers at lower (3°C) temperature.

Hard seed content can cause problems of uneven field emergence, but on the other hand, because of hard seeds, legumes usually present less problems than other species in storage. For planting purpose these seeds require some pretreatment so that they can germinate readily on sowing. Mechanically scarified/acid treated seeds can be safely stored upto almost a year without reduction in germination percentage. The advantage of these methods is that mechanical scarification is easy, cheap and could practically be used by the farmers, while sulphuric acid can be used by government and private seed multiplication and distribution organisation (who can afford the cost of such chemical) and distribute to farmers with the note that seeds should be stored properly and to be used before 12 months.

HARD SEEDEDNESS :

Within any seed lot not all the seeds are equally hard. The proportion of hard seed in a sample depends on the environmental conditions during the growth of plant, the degree of maturation of the seeds when collected and the length of the storage period. Mature seeds and those that have been stored for

several months or years usually have less than 10% of seeds that will germinate rapidly without pretreatment.

Hard seededness is a physical process and independant of whether the seed is alive or dead. It is therefore, a more direct measure of physical dormancy than germination, but on the otherhand not an expression of viability in the old seeds. Seeds of old age and those stored in bad storage conditions may become non-viable as their embryos loose the power of germination, but their seed coat may remain hard.

In the present study old seed lots of many species (***A. auriculiformis***; ***A. catechu*** Lot - 2, 3 & 4; ***A. nilotica*** Lot - 8, 9 & 10; ***Albizia lebbek*** Lot - 13, 14, 15 & 16; ***A. procera***; ***Cassia fistula*** Lot - 20, 21 & 22; ***C. siamea***; ***Parkinsonia***, ***Pithecellobium dulce*** Lot 34 & 35; ***P. samen*** and ***Prosopis juliflora*** Lot -38) possessed a good number of hard seeds (Table 57). Such seeds did not imbibe when soaked in water for 20 hours at room temperature. Even after many pretreatments applied (Table 4-39 in the observations), some seeds remained hard. Hundred percent imbibition was experienced only after the mechanical scarification but percent germination was very low, indicating that most of the hard seeds were not viable.

IMBIBITION :

Imbibition is also a purely physical process and therefore independent of wheather the seed is alive or dead. Seeds stored for a long duration or stored in adverse conditions for a short duration exhibited different imbibition and

Table 57: Percentage of imbibed, germinated, dead and hard seeds of various species after control and mechanical scarification (filing).

Lot No.	SPECIES	CONTROL (C)				FILING (MS)	
		Imb.	Ger.	Dead	Hard	Ger.	Dead
1.	*Acacia auriculiformis*	21	24	36	40	27	73
2.	*Acacia catechu*	65	--	100	--	--	100
3.	*Acacia catechu*	85	--	100	--	--	100
4.	*Acacia catechu*	79	--	100	--	--	100
5.	*Acacia catechu*	57	25	40	35	18	82
6.	*Acacia catechu*	13	11	87	2	32	68
7.	*Acacia catechu*	16	31	20	49	83	17
8.	*Acacia nilotica*	34	8	27	65	33	67
9.	*Acacia nilotica*	42	57	18	25	69	31
10.	*Acacia nilotica*	62	31	28	41	38	72
11.	*Acacia nilotica*	17	61	7	32	89	11
12.	*Acacia nilotica*	22	59	3	38	95	5
13.	*Albizia lebbek*	93	9	85	6	--	100
14.	*Albizia lebbek*	95	1	96	3	--	100
15.	*Albizia lebbek*	87	3	85	12	--	100
16.	*Albizia lebbek*	59	12	52	36	8	92
17.	*Albizia lebbek*	40	32	35	33	65	35
18.	*Albizia lebbek*	31	49	27	36	93	7
19.	*Albizia procera*	91	7	85	8	--	100
20.	*Cassia fistula*	11	14	23	63	28	72
21.	*Cassia fistula*	7	25	5	70	35	65
22.	*Cassia fistula*	6	5	21	74	31	69
23.	*Cassia fistula*	8	5	4	91	89	11

Table 57: (continued) Percentage of imbibed, germinated, dead and hard seeds of various species after control and mechanical scarification (filing).

Lot No.	SPECIES	CONTROL (C)				FILING (MS)	
		Imb.	Ger.	Dead	Hard	Ger.	Dead
24.	*Cassia fistula*	1	1	1	98	90	10
25.	*Cassia fistula*	5	6	5	89	87	13
26.	*Cassia siamea*	19	13	52	35	35	65
27.	*Delonix regia*	33	51	26	23	65	35
28.	*Delonix regia*	9	8	7	85	85	15
29.	*Delonix regia*	3	6	3	91	96	4
30.	*Leucaena leucocephala*	5	14	1	85	71	29
31.	*Leucaena leucocephala*	5	4	1	95	94	6
32.	*Leucaena leucocephala*	1	12	1	87	88	12
33.	*Parkinsonia aculeata*	17	8	59	33	18	82
34.	*Pithecellobium dulce*	57	--	60	40	--	100
35.	*Pithecellobium dulce*	25	13	87	--	13	87
36.	*Pithecellobium dulce*	10	15	13	72	81	19
37.	*Pithecellobium samen*	13	4	61	35	4	96
38.	*Prosopis juliflora*	9	--	80	20	--	100
39.	*Prosopis juliflora*	27	69	13	18	85	15
40.	*Prosopis juliflora*	31	63	11	26	79	21
41.	*Prosopis juliflora*	33	33	35	32	51	49
42.	*Prosopis juliflora*	15	65	4	31	92	8

Imb. - Imbibition after 20 hours

germination. Most of the old seed lots in the present study possessed the seeds which readily imbibed when soaked in water for 20 hours at room temperature. During germination studies, most of the imbibed seeds were found to be non-germinable. Only some such seeds were germinated in control (without any pretreatment).

EXCESSIVE IMBIBITION :

Mechanical scarification resulted in 100% imbibition and highest germination in most of the species/seed lots. But, in some cases, its negative effect was observed especially in some old seed lots of ***Acacia catechu*** (Lot 5) and ***Albizia lebbek*** (Lot 16). After 15 days, percentage germination in control was higher (Table 57) than that of mechanical scarification (***A. catechu*** : C-25% Vs 18% in MS; ***A. lebbek*** : C-12% Vs 8% in MS). It was noticed that some ungerminated seeds began to rot after 5-6 days after mechanical scarification. It may be probably the result of an excessive imbibition of tissue which leads to their asphyxia and necrosis. Similar findings have also been reported by Powell and Mathews (1978).

THE CAUSE AND NATURE OF HARD SEED COAT :

Many plant species have a seed coat which is impervious to water. This causes seed dormancy so that germination may extend over months or years.

The cause and nature of the seed coat impermeability are not fully understood, but it has been found that under natural conditions and after most

artificial treatments the first site at which water penetration occurs is the strophiole. This is the weakest and least reinforced area of seed coat and is seen as a small raised area close to the hilum but on the side opposite the micropyle (Cavanagh, 1980). Some authors have indicated the cuticle as the impermeable layer in legume seeds, while others have pointed out the role of the palisade cells in maintaining impermeability. In ***Albizia lophantha*** seed, both the cuticular layer and the palisade tissue are reported to prevent water uptake.

The barrier to water uptake in mature ***Cercis siliquastrum*** seeds appears to be due to the combined effect of the imperviousness of the hilum and the impermeability of the seed coat. Though all layers of the integuments are involved in maintaining impermeability, the inner non-cellular lipidic layer at the edge of the hypodermis is critical in preventing imbibition of endosperm and embryo (Riggio-Bevilacqua, ***et al.***, 1985).

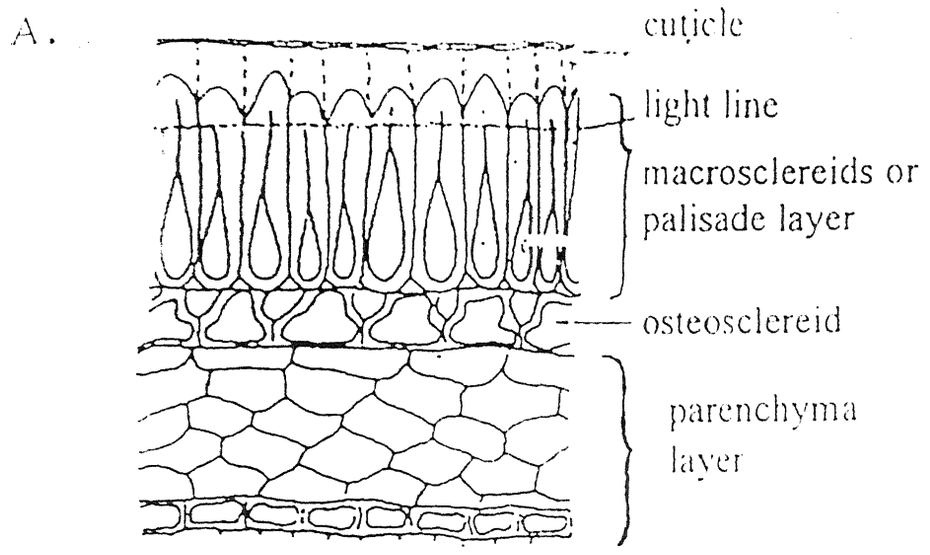
In ***Vicia*** spp. the entire seed coat was the site of impermeability. The result on elimination of hard seed condition due to piercing of seed coat indicated that the seed coat act as barrier to entry of water. It was observed that the epidermal layer near the hilum was separated, the counter- palisade parenchyma layer was bulging and the trachied bar cells were expanding in soft seeds compared to hard seeds. The entry of blue dye within 2 hours of soaking was observed through hilum in soft seed and the dye did not enter through epidermal layer of hard seed (Aswathaiah, 1988).

Seed envelop causes various type of inhibitions i.e. impermeability to water, impermeability to oxygen, mechanical barrier to radicle prostrusion etc. In case of mechanical scarification, the seed envelop is relatively better

scratched than other treatments. Therefore, all the above mentioned necessary processes for germination are initiated quickly, which ultimately result in higher germination percentages of seeds (Bohra ***et al.***, 1994).

The impermeability of the legume seed-coat is relative in the sense that various species, various stages of maturity and various individuals within an apparantly homogenous seed lot exhibit different degree of resistance to imbibition. The structure of seed- coat is given in Figure 8. It consists of four distinct layers : **1**) the cuticle is the outermost layer which has a waxy and water repellant character; **2**) macrosclereids or palisade layer which consists of long, narrow, tightly packed, vertical cells; **3**) osteosclereids which is a layer of more loosely packed cells; and **4**) parenchyma layer which is made up of a layer of little differentiated cells. Impermeability can be ascribed to the two outer layers, since it has been shown that once these layers have been penetreated, the seed readily absorbs water. The thickness of the total seed-coat as well as the relative thickness of the individual layers vary with species. For the seed-coat to become permeable, the palisade layer must be penetreated at least to the depth of the light line (Fig 8), (Schmidt, 2000).

The seed-coat structure is fairly uniform except for a few sites, with different cell arrangements. One site is the hilar region, which is the attachment site of the funicle and which contains the micropyle, hilum and strophiole. The cells of this region have a corky structure and no cuticle. The seed coat along the pleurogram, a horseshoe formed usually green line on e.g. ***Acacia*** and ***Albizia*** seeds is also slightly different. The hilar region and to a smaller degree the pleurogram are relatively weak sites of the seed-coat and most likely to



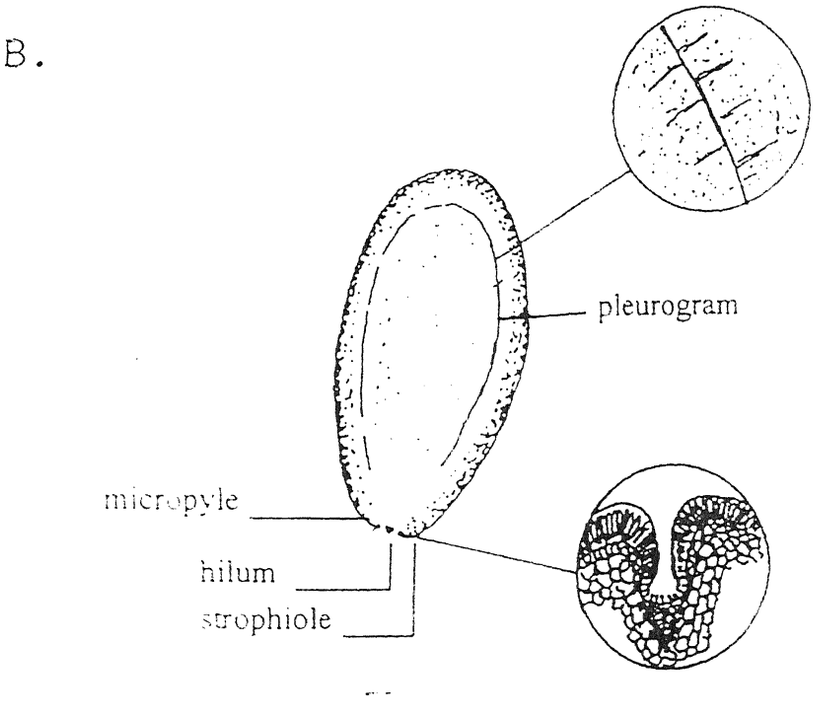


Figure 8: Legume seed: A. Cross section of the legume seed-coat. Seeds become permeable when the cuticle and the outer part of the palisade cells are penetrated. B. Entire seed with demarcation of 'weak sites', sites most likely to become permeable during pretreatment. Inserts: i) cracks along the pleurogram after hot water pretreatment; ii) cross section of the seed-coat in the strophiolar region.

become permeable during pretreatment. Hot water pretreatment is believed to influence permeability especially of the strophiole. However, any part of the seed-coat may be turned in to weaker site where water will ultimately penetrate (Schmidt, 2000).

As the seed loses water during maturation, the palisade cells of the seed-coat become more tightly packed and the seed-coat more impermeable. Thus, fresh legume seeds need no or less pretreatment than dry stored seeds. Physical dormancy also differs from one seed to another in a seed lot. Usually a few seeds in any seed lot will imbibe when submerged into water. Variation in germination percent and other characters may be due to variation in seed source (Gera ***et al.***, 1999).

CHAPTER - VII

SUMMARY

AND

CONCLUSIONS

SUMMARY

Seed dormancy refers to a state in which viable seeds fail to germinate when provided with conditions normally favourable to germination i.e. adequate moisture, appropriate temperature regime, a normal atmosphere and in some cases light. Several types of dormancy exist in various seeds. In nature, dormancy is broken gradually or by a particular environmental event. Dormancy caused by a hard seed - coat may be overcome by a gradual or an instant abrasion. In seed handling the natural dormancy breaking mechanism is applied or simulated during the process of pretreatment. Following trees producing hard coated seeds were taken for present work.

1. *Acacia auriculiformis*
2. *Acacia catechu*
3. *Acacia nilotica*
4. *Albizia lebbek*
5. *Cassia fistula*
6. *Cassia siamea*
7. *Delonix regia*
8. *Leucaena leucocephala*
9. *Parkinsonia aculeata*
10. *Pithecellobium dulce*
11. *Prosopis juliflora*

Studies were carried out in the Department of Botany, D.V. College, Orai (Jalaun).

SEED COLLECTION

Most of the seeds were collected from standing trees at the seeding time. Seeds were also obtained from seed supplier or seed agencies, from Forest Department and from the laboratory where old seeds were stored.

SEED GERMINATION :

Fresh pretreated and stored seeds were tested for germination in the laboratory. Three layered moistened sheet of filter paper spread on the germination trays of seed germinator served as the medium for germination.

SEED PRETREATMENTS :

It was observed that fresh as well as stored seeds of various species do not germinate and require some pretreatments to break their dormancy. Following pretreatments were applied.

1. CHEMICAL TREATMENT : Following chemicals were used to overcome seed - coat dormancy. Seed were soaked in -

(a) Potassium nitrate (KNO_3) - 10% for 10 and 20 hrs

(b) Potassium dichromate ($K_2Cr_2O_7$) - 5% for 10 and 20 hrs.

(c) Thiourea (H_2NCSNH_2) - 5% for 10 and 20 hrs.

(d) Sodium nitrite ($NaNO_2$) - 5% for 10 and 20 hrs.

(e) Cattle urine - 100% for 10 and 20 hours.

2. ACID SCARIFICATION :

(a) Concentrated HCl and HNO_3 for 60, 120 and 180 minutes.

(b) Concentrated (98%) Sulphuric acid - Duration of treatment was 1, 2, 3, 5, 10, 15, 30, 45, 60, 90 min and 3, 6 and 7 hours.

(c) Diluted Sulphuric acid - (i) 50% sulphuric acid (H_2SO_4) for 2, 5, 10, 30, 60, 90 and 180 minutes.

(ii) 10% sulphuric acid (H_2SO_4) for 10, 20 and 30 hours.

3. PHYSICAL PRETREATMENTS:

(a) Dry heat treatment -seeds were kept in the oven at

(i) 40°C for 5, 10 and 15 days ;

(ii) 60°C for 5, 10 and 15 days ; and

(iii) 80°C for 5 and 10 days.

(b) Hot water treatment - Seeds kept in water in oven at

(i) 40°C for 12 and 24 hours ;

(ii) 60°C for 5, 7 and 20 hours ; and

(iii) 80°C for 4, 11 and 20 hours

(c) Boiling water treatment - i) Boiling water dip and allow to cool.

ii) Kept in boiling water for 5, 10, 20 and 30 seconds and 1, 2 and 5 minutes.

(d) Shock treatment - i) Five seconds in boiling water then 5 seconds in ice water. 1, 2 and 5 times.

ii) Ten sec. in boiling water then 10 sec. in ice water for 1, 2 and 5 times.

4. **MECHANICAL SCARIFICATION** -

i) Abrassed on the iron paper (filing)

ii) Abrassed on a file (filing).

iii) Small cut on testa by scissors (nicking)

iv) Small cut on testa by cutter (clipping)

v) Hot iron rod touching (burning)

5. **Control** - Water soaked seeds served as control.

Imbibition: After each pretreatment, seeds were soaked in tap water at room temprature to see the effect of treatment on imbibition of seeds . After 20 hrs. all the seeds were taken out and kept in seed germinator for germination and vigour studies .

EXPERIMENTATION : All the pretreatments were conducted in 3 successive rounds each of which was comprised of some different treatments and took about 6 - 8 month period. Control and mechanical scarification of each lot was conducted with other treatments in each round. Effect of pretreatments on seed vigour was assessed by some vigour tests.

Effect of pretreatments on storage and effect of storage on pretreatment was evaluated by storing the seeds and seed viability was assessed by TTC test.

Performance of various pretreatments to the seeds of different species was as follows :

MECHANICAL SCARIFICATION : Mechanical scarification gave the best results in most of the species. Filing was found to be the best among various methods followed by nicking which was superior to clipping. Burning was the most sensitive in this method.

Percent germination of seeds of ***A. catechu*** was enhanced from 31% to 79 - 83% by nicking and filing ; ***A. nilotica*** (Lot 8) : 8% to 33% ;(Lot 9) : 57% to 69% ; (Lot 11) : 59 - 90% and 61 % to 89% by clipping and filing and of ***A. lebbek*** 32 % to 65% by filing. Hard coated seeds of ***C. fistula*** became permeable (Lot 23) : 5% to 81 - 89% ; (Lot 24) :1% to 86 - 90% and (Lot 25) : 6% to 87% by various methods of mechanical scarification. In ***D. regia,*** germination of seeds was enchanced from 8% to 85% by filing, 13 to 81% by nicking and 73% by burning method. Seeds of ***L. leucocephala*** (Lot no. 30, 31 and 32) also responded well to mechanical scarifications (4 to 25% in control to 71 - 94% germination). Seeds of ***Parkinsonia*** and ***Prosopis*** gave

highest germination by this treatment.

CONCENTRATED (98%) SULPHURIC ACID : Conc. H_2SO_4 was also found suitable almost in all the species to enhance the germination percentage (In ***A. auriculiformis*** : 23% to 40% in 60 min ; in ***A. catechu*** : 31 to 72 and 75% in 15 min.; in ***A. lebbek*** : 32% to 57 - 61% in 30 to 60 min ; in ***C. fistula*** : 1% to 76 - 85% in 45 to 90 min; in ***C. siamea*** : 9% to 29 - 30% in 30 - 45 min; in ***D. regia*** - 13% to 80% in 5 hrs; in ***L. leucocephala*** - 4% to 80% in 15 min ; in ***Parkinsonia*** 7 to 17% and in ***Prosopis*** 48% to 65% in 10 min). Acid treatment is effective for many species and can be carried out with simple equipments and at a low cost for materials as the acid is reusable. But, safety precautions require strict attention as conc. sulphuric acid is dangerous to the workers and materials. It should be handled at all times with great care.

Shock tratment (Boild water/ice water dip) gave best performance with the seeds of ***A. nilotica*** (59% to 88 - 93% in various times and durations), ***L. leucocephala*** (9% to 83% in 10 seconds for 5 times) and ***Parkinsonia*** (6% to 17 - 20% germination in various times and durations).

Boiled water gave the best results with the seeds of ***A. auriculiformis*** (21% to 43 and 45% germination in 10 and 20 sec.) and better performance in ***L. leucocephala*** (9% to 80 - 81% in 5 sec.) and ***Prosopis*** (33% to 46% in dipping) seeds to improve their germination.

Thiourea enhanced the seed germination of ***Pithecellobium*** from 13 to 21% (best in the species) but did not found to be useful to other species. No other chemical was found suitable to make the seed coat permeable.

PRETREATMENT AND SEED VIGOUR :

Effect of most suitable pretreatment on seed germination was evaluated in terms of seed vigour. Early and fast germination and production of well developed seedlings were the parameter of the vigour.

Germination velocity Index (GVI) :

It is an expression for 'speed of germination'. Germination counts are made every day and GVI is calculated by the following formula :

$$GVI = \frac{\text{Daily counts of germinated seeds}}{\text{Number of days of germination}}$$

GVI was found to be a reliable index for seed vigour in all the species. Pretreatments like mechanical scarification, boiling water, shock treatment and conc. H_2SO_4 treatments initiated early germination due to which higher values of GVI were obtained. Slow germinating seeds gave lower values of GVI.

Formation of vigour classes of seedlings :

It is virtually an expansion of the germination test to classify normal seedlings into a few vigour classes, each of which represents a stage of development of seedling.

Most suitable pretreatments to the seeds of various species were taken for this study. Germination of seed produced seedling of certain vigour in 15 days. These seedlings were classified into various vigour classes. It was observed that pretreatments like mechanical scarifications and shock/ boiling water treatment produced higher number of seedlings in vigour classes 1 and 2. Acid treated seeds also produced higher number of seedlings in 1 and 2 vigour classes than other treatments. Large number of seedlings in vigour class 1 and 2

produced by a treatment indicates its ability for the production of large number of seedlings in the nursery by hard coated seeds.

ASSESSMENT OF SEED VIABILITY BY TTC TEST :

Tetrazolium salt (2, 3, 5 - triphenyl tetrazolium chloride) when comes in contact with living tissue in seed embryos, gets reduced to an insoluble red colour pigment and stains the tissue. Non - living tissues do not affect reduction of tetrazolium salt.

After various pretreatments a good number of hard seeds remained at the end of the experiment. These seeds were mechanically scarified to get imbibed. Decoated seeds were kept in 0.1% TTC solution overnight and then evaluated for their viability. It was observed that most of the seeds of old seed lots were found in weak - germinable or non - germinable categories while those of new seed lots stained brightly. However, the assessment of viability by this test was slightly higher than the actual germination.

SEED STORAGE AND PRETREATMENT

Hard coated seeds are orthodox and have a long life span in proper storage conditions. But, after a decade or so, such seeds showed poor germination. Most of the old seeds of ***A. catechu***, ***A. lebbek***, ***A. procera***, ***P. dulce*** and ***P. juliflora*** showed extremely poor or nil germination. These seeds being >10 years of age have lost the vigour completely. However, many seeds were still hard and did not imbibed even after many pretreatments. After mechanical scarification, all the seeds imbibed but most of them could not germinate.

Seeds kept in various conditions to see the storage effect showed that

there was no difference in the process of mechanical scarification. All the stored seeds responded well to the treatment with slightly lower percentage germination in permeable containers at ambient (room temperature) conditions than those stored at 5°C.

STORAGE OF PRETREATED SEEDS :

Hard seed coat cause problem of uneven emergence in the nursery raising. This problem can be solved when pretreated seeds are supplied to the nurseries. Mechanically scarified / acid scarified and boiling or hot water scarified seeds are dried and stored in proper way. Air tight containers were used such as glass bottles and polythene packets and kept at room temperature as well as at low temperature (5°C) in the refrigerator. It was observed that pretreated seeds can be safely stored in air tight containers (15 - 35°C and at 5°C) upto almost a year without much reduction in germination percentage.

HARD SEEDEDNESS & IMBIBITION :

Hard seededness is a physical process and independant of whether the seed is alive or dead. It is therefore, a mere direct measure of physical dormancy than germination, but on the otherhand not an expression of viability. Old seed lots of many species (***A. auriculiformis***, ***A. catechu***, ***A. nilotica***, ***A. lebbek***, ***C. fistula***, ***C. siamea***, ***Parkinsonia***, ***Pithecellobium*** and ***Prosopis***) possessed a good number of hard seeds which remained as such even after many pretreatments. After mechanical scarification it was revealed that most of them were not able to germinate. Thus, seed may be hard but not necessarily viable especially in old seed lot.

Imbibition is also a physical process and some seeds always imbibe

readily in each seed lot when soaked in water. Older the seed lot, larger the number of such seeds. In an old seed lot many of the readily imbibed seeds do not germinate i.e. they are non viable. But some seed germinate slowly without any physical or mechanical pretreatment. If some treatments are applied to the seed lots, percentage germination was found to be lower than control. It may be due to heat or mechanical injury or due to excessive imbibition (asphyxia) which leads to their death resulting low percentage germination.

CAUSE AND NATURE OF HARD SEED COAT:

Seed envelop causes various types of inhibitions i.e. impermeability to water, to oxygen, mechanical barrier etc. Some authors have indicated that the cuticle is the impermeable layer in legume seeds, while others have pointed out the role of the palisade cells in seed hardness. Some reported that cuticle and palisade, both prevent water uptake.

The first site at which water penetration occurs, is the strophiole. This is the weakest and least reinforced area of seed coat and is seen as a small raised area close to the hilum. Water absorption capacity and germination of seed depend to a great extent on the structure of hilum and the micropyle besides that of seed coat.

Some workers using scanning electron microscopy observed that disintegration of the seed coat material as well as micropylar plug may be the reason for increase in water absorption and subsequent germination of seeds after concentrated sulphuric acid treatment. Soaking in conc. sulphuric acid is the most common method of treating hard coated seeds. The effect on the seed coat is similar to that of boiling water and the seed coat is left dull and shallowly

pitted. It is a more effective method than boiling water.

Mechanical scarification is very effective, safe and cheap technique and is recommended for pretreating hard coated seeds before germination when sowing small and valuable research seedlots for seed testing laboratory and gene banks. The disadvantages are the slowness of application and the care required not to cut away too much of the seed, thus damaging the embryo.

CONCLUSIONS

For better performance of a nursery, seeds of good quality and their proper pretreatment is necessary. It can be achieved by some general steps taken during seed collection, storage and pretreatment.

1. Seeds should be collected when they are fully ripe. Better to pluck the ripen pods directly from the standing trees.
2. Collection should be done in the supervision of technical expert in this field.
3. Extracted seeds should be dried well in the sun and stored in the sealed containers.
4. Some seeds are palatable to the insects in the storage so they must be kept mixed with insecticide.
5. Mechanical scarification is safest and the best pretreatment in larger seeds. Hard seed coats are easily scratched with a file or iron paper.
6. Filing should be done at the end opposite to the radicle or on flat surface.
7. Nicking and clipping should also be done at the opposite to the radicle

end and care to taken not to cut the portion of endosperm or cotyledon.

8. Hot Iron rod touching (burning) is quite easy but its duration for different seeds should be worked out otherwise seed injury may occure.
9. Acid treatment should be done with special care as it may injure the worker and the seeds.
10. Seeds must be sinked in the acid for the prescribed duration. It may be done by stiring with glass rod.
11. After acid treatment, seeds must be rinsed in water well so that no acid coating may remain on the seed.
12. Acid pretreated seeds must be dried and kept in sealed containers if they are to be sown after some time.
13. Boiling / hot water for short duration is beneficial in breaking the seed coat imposed dormancy in many seeds but longer duration at higher temperature generally injure the embryo.
14. Shock treatment is more effective in some species as seeds are dipped in boiled / ice water for a very short duration.
15. Old seeds should not be used for raising the nursery. They may be hard but may loose their viability.

CHAPTER - VIII

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